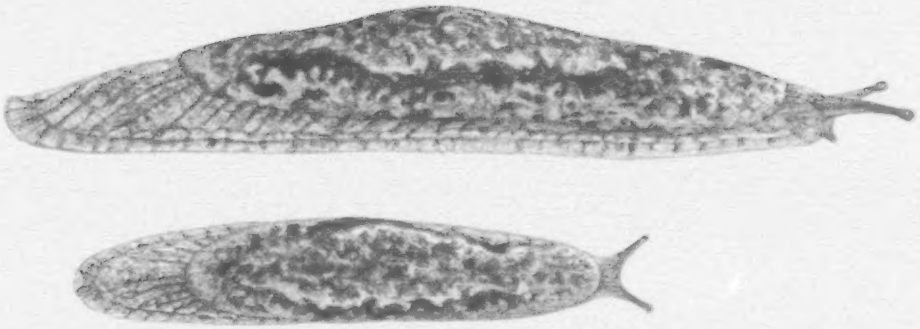
COSEWIC
Assessment and Status Report

on the

Magnum Mantleslug
Magnipelta mycophaga

in Canada



SPECIAL CONCERN
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2012. COSEWIC assessment and status report on the Magnum Mantleslug *Magnipelta mycophaga* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 41 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Production note:
COSEWIC would like to acknowledge Dr. Kristiina Ovaska and Lennart Sopuck for writing the status report on the Magnum Mantleslug *Magnipelta mycophaga* in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Dr. Dwayne Lepitzki, Co-chair of the COSEWIC Molluscs Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Limace à grand manteau (*Magnipelta mycophaga*) au Canada.

Cover illustration/photo:
Magnum Mantleslug — Aleta Karstad generously allowed the use of her painting of the Magnum Mantleslug on the title page.

©Her Majesty the Queen in Right of Canada, 2012.
Catalogue No. CW69-14/657-2012E-PDF
ISBN 978-1-100-20723-0

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – May 2012

Common name
Magnum Mantleslug

Scientific name
Magnipelta mycophaga

Status
Special Concern

Reason for designation
This large slug, up to 80 mm in length, is regionally endemic to the northern Columbia Basin in western North America. About half of the species' global range extends into southeastern British Columbia. It occurs in a number of widely separated habitat patches and is confined to cool, moist places in coniferous forests at mid- to high elevations. While hundreds of sites have been searched for slugs and land snails within the range of this slug, mostly within the past decade, as of November 2010 there are only 13 records for it in Canada. Since the 1960s its habitat has become increasingly fragmented. The number and variety of threats including logging, recreational developments and activities, wildfire, and changes in moisture regimes caused by climate change increase the level of risk.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2012.

COSEWIC
Executive Summary

Magnum Mantleslug
Magnipelta mycophaga

Wildlife Species Description and Significance

The Magnum Mantleslug is the sole member of the genus *Magnipelta*. It is a large slug up to 80 mm in length. Its most distinctive feature is a large mantle, which covers most of the back. The body is tan-brown with uneven black spotting; there is an irregular dark stripe on each side of the mantle. The species is regionally endemic to the northern Columbia Basin and adjacent mountains, an area that contains many unique plants and animals.

Distribution

The Magnum Mantleslug occurs in southeastern British Columbia (BC), northwestern Montana, northern Idaho, and extreme northeastern Washington. About half of the species' global distribution is in BC; the remainder is mostly in Montana. In BC, the species distribution extends from the Canada – US border north to Wells Gray Provincial Park and from near Trail east to Fernie. This distribution encompasses portions of the Rocky Mountains, Columbia Mountains (Purcell, Selkirk, and Monashee ranges), and Shuswap Highlands. The distribution of the species is extremely patchy within this large range, possibly reflecting the availability of suitable moist habitats and low dispersal abilities of the slugs. As of November 2010, there are 13 records of the species from scattered sites, assigned to nine populations. Hundreds of sites have been searched for slugs and land snails within the distribution of this species, mostly within the past 10 years.

Habitat

The Magnum Mantleslug occupies coniferous forests at mid- to high elevations and requires cool, moist conditions. In BC, the species has been found in Interior Cedar-Hemlock and Engelmann Spruce–Sub-alpine Fir biogeoclimatic zones at elevations of 800 - 2060 m. The slugs inhabit very moist microsites, often with abundant herbaceous vegetation such as found in splash zones of cascading creeks and avalanche chutes, but also occur on the forest floor under heavily shaded forest canopy. The slugs are often associated with decaying logs and other coarse woody debris and have also been found under rocks in stable talus in moist situations.

From 1960 to present, habitats of the Magnum Mantleslug in Canada have become increasingly fragmented mainly due to logging, agriculture, ranching, mining, hydro development, transportation corridors and land conversions to residential areas. Considerable areas of mid- to high elevation forests are still intact due to a network of protected areas and inaccessible terrain, but logging and other resource extraction activities continue to expand in higher elevation forests.

Biology

Very little is known of the life cycle of the Magnum Mantleslug. The species is hermaphroditic, possessing both female and male reproductive organs, but exchange of sperm with other individuals, rather than self-fertilization, is probably the norm similar to most other slugs. The slugs lay eggs and can live more than 1 year; whether individuals are capable of reproducing in their first year is unknown but possible. The slugs are active during moist conditions from spring to autumn and seem to prefer substrate temperatures of 12 - 15°C. Their requirements for cool, moist microhabitats probably limit their distribution within the landscape and increase their vulnerability to human activities that alter hydrology or forest floor microclimates. The species is expected to have poor dispersal abilities similar to other terrestrial gastropods.

These slugs exhibit an unusual behaviour in response to disturbance. If provoked, the slug is prone to spread its large mantle in a wing-like fashion. This behaviour perhaps startles a predator or exaggerates the slug's body size, making it appear too large to swallow.

Population Sizes and Trends

No estimates of population sizes or trends are available. There are 13 records of the species from BC, representing a total of only 15 individuals, from 1992 - 2010. New sites continue to be found with increasing search effort. However, it is clear that the species' distribution is extremely uneven, even in apparently suitable habitats. Some habitat patches are small, raising questions about long-term viability of the populations. All six sites where the species had been found previously were visited in 2010; the species was found only near one of the sites, as well as at two new sites in the intervening areas. Given the species' patchy distribution across the landscape, poor dispersal ability, and the scattered distribution of suitable moist habitat patches, it is highly probable that populations have been lost over the past century and continue to be lost as a result of habitat degradation.

Threats and Limiting Factors

At known sites, the species is threatened by logging, recreational developments and activities, wildfire, and climate change. Logging is pervasive throughout the species' range, and five of 10 occupied sites are on forestry lands. Logging alters temperature and moisture regimes on the forest floor and can disturb or destroy habitat patches. Logging roads have increased public access to the backcountry, including off-road vehicle use that compacts soil and can destroy habitat patches used by the slugs. Recreational developments and activities, such as ski hill developments, are localized but expanding within the species' range. Infrastructure development and heavy recreational use can result in soil compaction and damage to understorey vegetation, posing threats to slug habitats. Strip-mining for coal is expanding in the southeastern part of the species' range in Canada.

The frequency and extent of wildfires is expected to increase with climate change and Mountain Pine Beetle infestations that are sweeping across interior BC. Terrestrial gastropods are thought to be sensitive to fire, which can decimate habitats and individuals, but the ability of the Magnum Mantleslug to survive fire events and persist in burned areas is unknown. Increased mortality due to the toxic effects of fire retardant chemicals is also a potential threat. Climate change is predicted to result in shifts in habitats and ecosystems over the next decades. Species occupying higher elevation habitats, such as the Magnum Mantleslug, might be especially vulnerable to shifts in habitats and ecosystems along altitudinal gradients, but the magnitude of such effects is uncertain.

Protection, Status, and Ranks

The Magnum Mantleslug has no official protection or status under the federal *Species at Risk Act*, BC *Wildlife Act*, or other legislation. It is ranked by NatureServe as follows: Global status: G3 - vulnerable; United States: N3 - vulnerable; Canada: N2N3 - imperiled to vulnerable; Idaho: SNR - not assessed; Montana: S1S3 - critically imperiled to vulnerable; Washington: S2 - imperiled; British Columbia: S2S3 - imperiled to vulnerable. In addition, the species is on the provincial blue list of species at risk (currently under reassessment).

The species has been recorded from Mount Revelstoke National Park, two provincial parks (Wells Gray and Stagleap), and a recently protected area owned by the Nature Conservancy of Canada. The remaining known sites are on private or provincial forestry lands and private resort properties.

TECHNICAL SUMMARY

Magnipelta mycophaga
Magnum Mantleslug — Limace à grand manteau
Range of occurrence in Canada (province/territory/ocean): British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used) - *Unknown but individuals live multiple years*	≥1 yr
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? *Based on decline in extent and quality of habitat*	Probably
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	NA
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	NA
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	NA
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	NA
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	40,813 km²
Index of area of occupancy (IAO) *Based on 2 km x 2 km grids superimposed on the Canadian distribution; 12 km² if 1 km x 1 km grids are used; the smaller grid size may be more appropriate given the occurrence of the species in small patches of suitable habitat. It is probable that additional, undocumented occurrences exist and would increase the IAO*	48 km²
Is the total population severely fragmented? *Population sizes and their viability are unknown: 9 isolated populations, most of which are known from 1 record only, representing 1 - 4 individuals.*	Possibly
Number of locations* *10 - 12 based on threats to known sites from logging, wildfires, and recreational developments/activities; other undocumented locations with these threats probably exist within the species' large Canadian range. Conversely, the number of locations could be 9 or lower for the threat of climate change, but the effects and their timing are uncertain.*	9 - 12
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Possibly

* See definition of location.

Is there an [observed, inferred, or projected] continuing decline in number of populations? *Decline possible with continuing loss and alteration of habitat*	Possibly
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Unknown
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? *Logging and other human activities continue to degrade habitat throughout the species' range as would climate change*	Yes
Are there extreme fluctuations in number of populations?	Unknown but unlikely
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	Unknown but unlikely

Number of Mature Individuals (in each population)

Population	N Mature Individuals
9 known populations: Barrière; Sicamous; Monashee Mountains (Castlegar); Wells Gray; Mt. Revelstoke; Salmo; Kootenay Pass (Stagleap); Lizard Range (Fernie); Morrissey Ridge (Fernie): Only 1 - 4 individuals per population have been found to date	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not done

Threats (actual or imminent, to populations or habitats)

Logging – pervasive throughout the species' range (5 of 10 occupied sites are on forestry lands); logging alters temperature and moisture regimes on the forest floor and can disturb or destroy habitat patches where the slugs occur; logging roads compact soil, have the potential to cause erosion, and increase access to humans and invasive plants and gastropods.
Recreational developments and activities – localized but expanding, such as ski hill developments, within the species' range; infrastructure development and heavy recreational use can result in soil compaction and damage to understorey vegetation, posing threats to slug habitats.
Wildfire – pervasive; frequency of fires is expected to increase with climate change; terrestrial gastropods are thought to be sensitive to fire, which can decimate habitats and subpopulations, but the effects on this species are unstudied. Fire retardants broadcast in the environment are also a potential hazard.
Climate change – pervasive; shifts in habitats and ecosystems and shrinking of moist habitat patches occupied by the species are possible, but the magnitude of the effects is uncertain. Higher elevation habitats occupied by the species might be especially vulnerable. Climate change is also likely to increase spread of invasive species, including introduced terrestrial gastropods, to higher elevation habitats.
Other threats across the species' range include mining, ranching, and residential development in localized areas.

---

* See definition of location.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? United States: N3 - vulnerable; Idaho: SNR - not assessed; Montana: S1S3 - critically imperiled to vulnerable; Washington: S2 - imperiled	
Is immigration known or possible? *Two routes identified: (1) from northwestern Montana through the Flathead Valley along lower, western slopes of the Rocky Mountains, where the species has been recorded south of the border; (2) through Idaho Panhandle along north-south–oriented mountain range, where there are recent records of the species south of the Canadian border.*	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Possibly
Is rescue from outside populations likely? *Although possible, dispersal from the US is unlikely over the short term given the species' poor dispersal ability and patchiness of pockets of suitable habitat*	Possible but unlikely

Current Status

COSEWIC: Special Concern (2012)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	not applicable
Reasons for designation: This large slug, up to 80 mm in length, is regionally endemic to the northern Columbia Basin in western North America. About half of the species' global range extends into southeastern British Columbia. It occurs in a number of widely separated habitat patches and is confined to cool, moist places in coniferous forests at mid- to high elevations. While hundreds of sites have been searched for slugs and land snails within the range of this slug, mostly within the past decade, as of November 2010 there are only 13 records for it in Canada. Since the 1960s its habitat has become increasingly fragmented. The number and variety of threats including logging, recreational developments and activities, wildfire, and changes in moisture regimes caused by climate change increase the level of risk.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable as no estimates of population size or trends are available.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EO (40, 813 km^2) exceeds the threshold for Threatened (< 20,000 km^2) and, while the IAO (48 km^2) is below the threshold for Endangered (< 500 km^2) and Threatened (< 2,000 km^2), the population is not severely fragmented and the number of locations exceeds the thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable as no estimates of population size or trends are available.
Criterion D (Very Small or Restricted Total Population): Not applicable. There are no estimates of population sizes, IAO (48 km^2) exceeds the threshold of 20 km^2, there are most likely more than 5 locations and while the effects of identified threats are continuing, they will mostly likely not act in a very short time frame.
Criterion E (Quantitative Analysis): Not applicable as no estimates of population size or trends are available and no quantitative analyses have been performed.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada | Environnement Canada
Canadian Wildlife Service | Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Magnum Mantleslug

Magnipelta mycophaga

in Canada

2012

TABLE OF CONTENTS

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE 4
- Name and Classification 4
- Morphological Description 5
- Population Spatial Structure and Variability 6
- Designatable Units 6
- Special Significance 6

DISTRIBUTION 7
- Global Range 7
- Canadian Range 10
- Extent of Occurrence and Area of Occupancy 12
- Search Effort 12

HABITAT 15
- Habitat Requirements 15
- Habitat Trends 21

BIOLOGY 22
- Life Cycle and Reproduction 22
- Seasonal Activity 23
- Diet 23
- Behaviour 23
- Physiology and Adaptability 23
- Dispersal and Migration 24
- Interspecific Interactions 24

POPULATION SIZES AND TRENDS 24
- Sampling Effort and Methods 24
- Abundance and Fragmentation 25
- Fluctuations and Trends 26
- Rescue Effect 26

THREATS AND LIMITING FACTORS 27
- Limiting Factors 27
- IUCN Threats Calculator 27
- Logging & Wood Harvesting (impact: medium) 27
- Climate Change (impact: medium - low) 29
- Housing & Urban Areas (impact: low) 30
- Livestock Farming & Ranching (impact: low) 30
- Mining & Quarrying (impact: low) 30
- Transportation & Service Corridors (impact: low) 30
- Recreational Activities (impact: low) 31
- Fire and Fire Suppression (impact: low) 31
- Invasive and non-native alien species (impact: unknown) 31
- Number of Locations 32

PROTECTION, STATUS, AND RANKS 34
- Legal Protection and Status 34
- Non-Legal Status and Ranks 34
- Habitat Protection and Ownership 34

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED 35
INFORMATION SOURCES 36
BIOGRAPHICAL SUMMARY OF REPORT WRITERS 39
COLLECTIONS EXAMINED 39

List of Figures

Figure 1. Magnum Mantleslug, *Magnipelta mycophaga*. Lizard Range, near Fernie, BC (photo by K. Ovaska). 5
Figure 2. Global distribution of Magnum Mantleslug. Eastern boundaries in Idaho and Washington are approximate (map prepared by Lennart Sopuck). 8
Figure 3. Canadian distribution of Magnum Mantleslug, based on records from 1992 - 2010 (map prepared by Jenny Wu, COSEWIC Secretariat) 11
Figure 4. Overview of sites surveyed for terrestrial gastropods within the range of Magnum Mantleslug in southeastern British Columbia. Red symbols – sites surveyed in 2010, as part of the preparation of this status report (map prepared by Lennart Sopuck). 14
Figure 5. Magnum Mantleslug habitat on Lizard Range, near Fernie, BC. The species was found in the seepage zone of a cascading creek supporting dense shrubs and herbs (red circle and insert) (photos by Lennart Sopuck & Kristiina Ovaska). 18
Figure 6. Magnum Mantleslug habitat near Morrissey Ridge east of Fernie, BC. The species was found in shaded, moist, northeast facing slope (right) (photo by Lennart Sopuck). 19
Figure 7. Magnum Mantleslug habitat near Kootenay Pass, BC. (photo by Robert Forsyth). 20
Figure 8. Example of logging in Magnum Mantleslug habitat. The pin denotes a site where the species was found southeast of Fernie, BC. 29

List of Tables

Table 1. Distribution records for Magnum Mantleslug from British Columbia. Coordinates are rounded up to mask exact locations. 9
Table 2. Summary of survey effort for terrestrial gastropods and the Magnum Mantleslug in British Columbia, 1990 - 2010. 13
Table 3. Habitat at sites where Magnum Mantleslug has been found in British Columbia. BEC: British Columbia biogeoclimatic zone (Meidinger and Pojar 1991); ESSF: Engelmann Spruce – Subalpine Fir; ICH: Interior Cedar-Hemlock 16
Table 4. Habitat disturbance at sites where Magnum Mantleslug has been found in British Columbia. % refers to approximate percentage of land subjected to different land uses within about 1 km and 10 km radius area around slug records, as determined visually from Google Earth orthophotos. 28
Table 5. Threat assessment for Magnum Mantleslug, using IUCN threat categories and calculator. Only categories with non-zero ratings are shown. 32

List of Appendices

Appendix 1. Distribution of searches for terrestrial molluscs in British Columbia and neighbouring provinces and territories from 1999 through September 2011. Each dot represents a locality where a search for terrestrial snails and slugs has occurred; methodology includes visual searches with or without substrate manipulation as well as forest floor litter samples. This compilation only includes records from Biolinx Environmental Research Ltd., Forsyth, and Wildlife Systems Research (= Lepitzki); some of these records have been included in reports and publications while other records are unpublished (map prepared by R. Forsyth). 40

Appendix 2. Sites surveyed for terrestrial gastropods in the Kootenays by Biolinx Environmental Research Ltd. from 2008 - 2010, showing observations of *Hemphillia camelus* (Pale Jumping-slug) and *Magnipelta mycophaga* (Magnum Mantleslug). 41

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Magnipelta mycophaga Pilsbry, 1953 (Magnum Mantleslug) is a member of the large cosmopolitan family Arionidae. The genus is monotypic with no other described species (Turgeon *et al.* 1998). The species was described from a single immature specimen collected in 1948 near Lolo Pass in northeastern Idaho (Pilsbry 1953). Pilsbry and Brunson (1954) expanded the description based on additional adult specimens from western Montana.

The genus *Magnipelta* was placed in the family Arionidae, subfamily Ariolimacinae, the latter of which is a small group of slugs endemic to western North America (Pilsbry 1948, 1953; Pilsbry and Brunson 1954). However, *Magnipelta* appears only remotely related to other genera (*Ariolimax*, *Zacoleus*) in the group (Pilsbry 1953; Pilsbry and Brunson 1954). An alternative classification by Bouchet and Rocroi (2005) raises all arionid subfamilies to full family status (Ariolimacinae becomes Ariolimacidae). Neither of these classifications is satisfactory because current genetic studies do not support the monophyly of Arionidae or Ariolimacinae/Ariolimacidae (Backeljau pers. comm. 2011). Although Webb and Russell (1977) suggested that *Magnipelta* is more closely associated with Camaenidae than Arionidae, based on features of the genitalia, this suggestion has not gained further support.

The classification of the species is as follows: Phylum Mollusca, Class Gastropoda, Subclass Orthogastropoda, Order Pulmonata, Suborder Eupulmonata, Infraorder Stylommatophora (clade in classification by Bouchet and Rocroi 2005), Superfamily Arionoidea, Family Arionidae (or Ariolimacidae), Genus *Magnipelta,* Species *M. mycophaga*.

The scientific name of the genus refers to the distinctive large mantle and the species name to the mushrooms on which the type specimen was found feeding (Pilsbry 1953). The English common name is also in reference to the large mantle (Turgeon *et al.* 1998). The species was previously referred to as Spotted Slug, but this name is sometimes also applied to *Limax maximus* (Turgeon *et al.* 1998). The French name is limace à grand manteau.

Morphological Description

The Magnum Mantleslug is a robust, large slug up to 80 mm in length when extended (Brunson and Kevern 1963). The most distinctive feature is a large mantle, which covers most of the back in living animals and at least two-thirds of the body length in specimens preserved in alcohol (Pilsbry 1953; Pilsbry and Brunson 1954) (Figure 1). The mantle is "smooth, chamois coloured, with an irregular black stripe on each side and elsewhere unevenly spotted with black" (Pilsbry 1953). The oval shell plate is calcareous and covered by the mantle. The respiratory pore is slit-shaped and approximately in the middle of the mantle margin on the right side; it may be slightly posterior (Pilsbry 1953) or anterior (Pilsbry and Brunson 1954) of the median. The anterior end of the mantle is free for about one-quarter of its length and shortly free posteriorly. The foot is lighter in colour than the mantle and contains black spotting. The pedal margin is narrow with distinct pedal grooves. The sole is wrinkled transversely along the edges, but is not distinctly tripartite. There is no caudal gland or pit above the tail. Internal anatomy, including illustrations of genitalia, are shown in Pilsbry (1953; immature specimen only), Pilsbry and Brunson (1954), and Webb and Russell (1977).

Figure 1. Magnum Mantleslug, *Magnipelta mycophaga*. Lizard Range, near Fernie, BC (photo by K. Ovaska).

The large size and large mantle that covers most of the body length distinguish this species from all other sympatric slugs. Two recently described slugs from western North America also have a large mantle (*Securicauda hermani* and *Carinacauda stormi*); *S. hermani* occurs within the range of the Magnum Mantleslug in Idaho (Leonard *et al.* 2011). That species is much smaller (adult body length < 10 mm) but could be confused with juveniles of the Magnum Mantleslug, necessitating careful examination of all juvenile *S. hermani*. Juvenile Magnum Mantleslugs are expected to be larger (>10 mm) and more robust.

Population Spatial Structure and Variability

Nothing is known of the genetic structure of populations in Canada or in the United States. In Canada, the species is known from only nine widely separated populations (see **Canadian Range**). The spatially closest populations (Lizard Range and Morrissey, near Fernie) are 12 km apart at their nearest points but are separated by the wide Elk Valley, which is largely developed and modified and does not provide suitable habitat. The other populations are separated from the nearest population by distances of 55 - 77 km. While it is probable that the species exists in additional, undocumented sites in some of the intervening areas, strong demographic isolation of populations is inferred from poor dispersal abilities of the slugs, habitat fragmentation from human developments and activities, and natural barriers (see **Habitat Trends**). The requirement for very moist, cool habitats (see **Habitat Requirements**) is expected to further constrain movements and pose barriers to dispersal and gene flow.

Designatable Units

There is no evidence to suggest that populations in Canada are ecologically or genetically distinct to a degree that warrants the establishment of more than one designatable unit.

Special Significance

The Magnum Mantleslug is a regional endemic to moist forests of the northern Columbia Basin and adjacent highlands and mountains, an area that contains many unique plants and animals (Brunsfeld *et al.* 2001). This unique area extends from southeastern BC and northeastern Washington through the Idaho Panhandle to northwestern Montana.

Similar to other herbivorous/fungivorous slugs (such as Pacific Banana Slug, *Ariolimax columbianus*: Gervais *et al.* 1998; Blue-grey Taildropper, *Prophysaon coeruleum*: McGraw *et al.* 2002), this species probably contributes locally to ecosystem processes by aiding nutrient cycling and by dispersing seeds of understorey plants and spores of mushrooms and other fungi that the slugs ingest and later deposit in their feces. This species is the sole representative of its genus and stands alone within western North American arionids. Therefore, it is of evolutionary interest to science. No Aboriginal Traditional Knowledge pertaining to the species was available to the status report writers.

DISTRIBUTION

Global Range

The Magnum Mantleslug occurs in southeastern-central British Columbia (BC), northwestern Montana, northern Idaho, and extreme northeastern Washington (US: Frest and Johannes 1995; Montana Field Guide, undated; Canada: Forsyth 2004; Figure 2). About half of the species' distribution is in BC; the remainder is largely in Montana, where the species has been found in Flathead, Granite, Lincoln, Mineral, Missoula, and Sanders counties (Montana Field Guide, undated). Its distribution in Idaho and Washington, including the western limits, is poorly known. The species occurs in mid- to high elevations with records from 760 - 2050 m in the US (Montana Field Guide, undated) and from 800 - 2060 m in BC (Table 1).

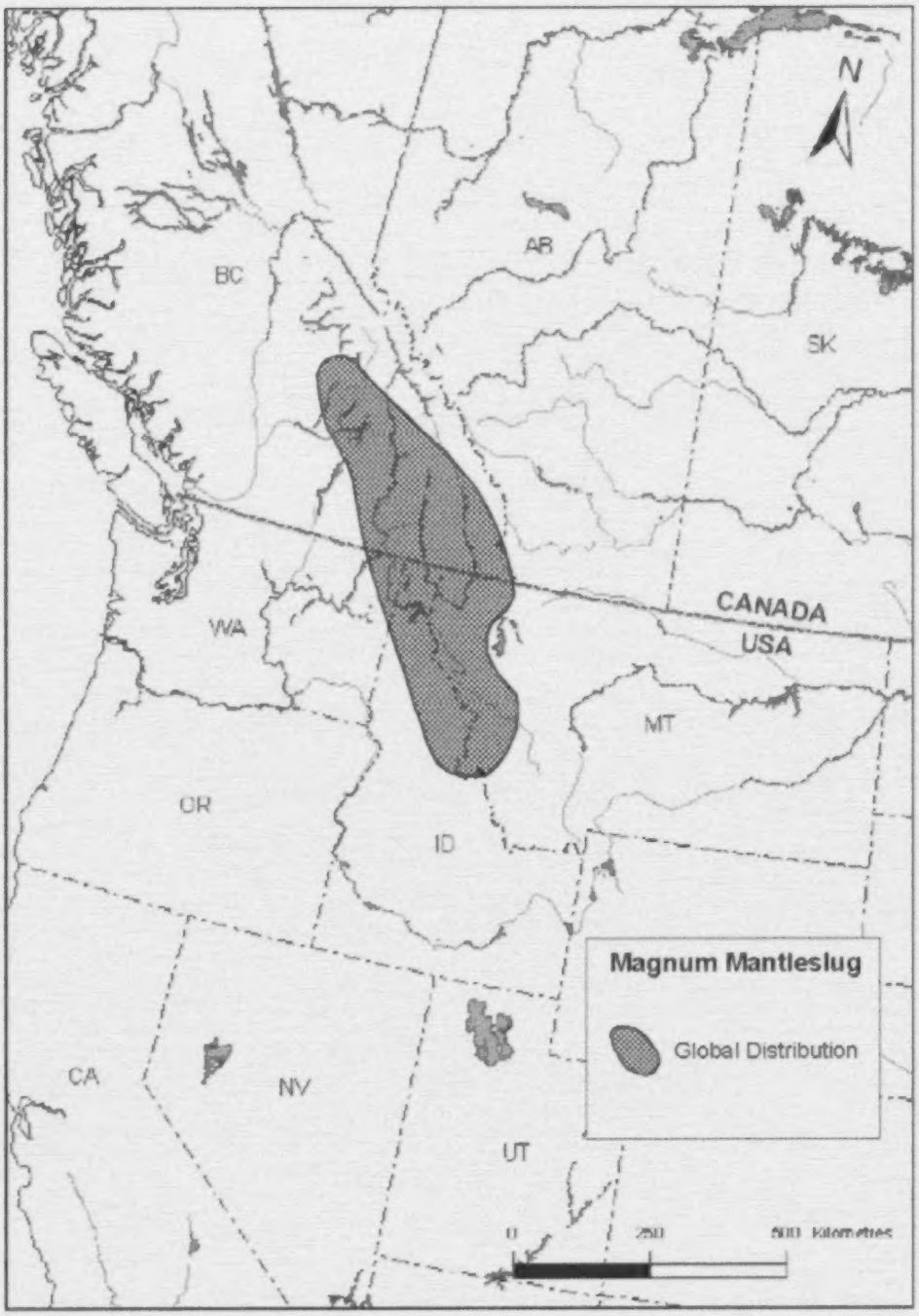


Figure 2. Global distribution of Magnum Mantleslug. Eastern boundaries in Idaho and Washington are approximate (map prepared by Lennart Sopuck).

Table 1. Distribution records for Magnum Mantleslug from British Columbia. Coordinates are rounded up to mask exact locations.

Record #	Date	No. of slugs	Population	Site name	Latitude (°N)	Longitude (°W)	Elev. (m)	Land status	Collector/ observer	Source
1-2	Aug 1992; Aug 1993	2 (3 m apart; 1 year apart)	Barrière	East Barrière Lake, ca. 30 km NE of Barrière, Shuswap Highlands	51.2	119.8	1400	BC crown (forestry lands)	Dave Huggard	D. Huggard (pers. comm. 2009); ID by Terry Frest
3	Aug-93	2 (100 m apart)	Sicamous	Sicamous Creek, ca.7 km ESE of Sicamous, west slope of Monashee Mountains	50.8	118.9	1550	BC crown (forestry lands)	Dave Huggard	D. Huggard (pers. comm. 2009); ID by Terry Frest
4	23-Sep-98	1	Monashee Mountains (Castlegar)	Near Nancy Greene Park, ca. 20 km W of Castlegar, Monashee Mountains	49.3	117.9	1275	BC crown (forestry lands)	Kelly Sendall	RBCM (998-00280-003)
5	18-Aug-02	1	Kootenay Pass (Stagleap)	Stagleap Provincial Park, NE of Ripple Mountain, Selkirk Mountains (Nelson Range)	49.0	117.1	2055	Provincial park	Robert Forsyth	RBCM (002-00158-001); R. Forsyth (pers. comm. 2010 & photograph published in Forsyth 2004)
6	11-Aug-09	1	Kootenay Pass (Stagleap)	Stagleap Provincial Park, Selkirk Mountains (Nelson Range)	49.1	117.0	1860	Provincial park	James Miskelly	J. Miskelly (pers. comm. 2010); inspected by K. Ovaska
7	11-Sep-04	1	Wells Gray	Wells Gray Provincial Park: near Dawson Falls, Shuswap Highlands	52.0	120.1	800	Provincial park	Heike Reise	H. Reise (pers. comm. 2010)
8	13-Jul-07	1	Lizard Range (Fernie)	Lizard Range, ca. 4 km SW of Fernie, Rocky Mountains	49.5	115.1	1476	Private (resort/ recreational)	Kristiina Ovaska & Lennart Sopuck	Ovaska and Sopuck (2008)
9	18-Aug-09	1	Lizard Range (Fernie)	Lizard Range, ca. 5 km SW of Fernie, Rocky Mountain range	49.5	115.1	1200	Private (resort/ recreational)	Claudia Copley	C. Copley & J. Miskelly (pers. comms. 2010); inspected by K. Ovaska
10	13-Sep-10	1	Lizard Range (Fernie)	Lizard Range, ca. 12 km SW of Fernie, Rocky Mountain range	49.5	115.2	1580	Private (resort/ recreational)	Lennart Sopuck & Christian Engelstoft	Ovaska and Sopuck (this report)
11	7-Sep-10	1	Mt. Revelstoke	Mt. Revelstoke, Mount Revelstoke National Park, Rocky Mountain range	51.0	118.1	1403	National park	Lennart Sopuck & Kristiina Ovaska	Ovaska and Sopuck (this report)
12	14-Sep-10	4	Morrissey Ridge (Fernie)	Morrissey Ridge, near Fernie, Rocky Mountain range	49.4	114.9	1614	Private (forestry lands)	Lennart Sopuck & Christian Engelstoft	Ovaska and Sopuck (this report); Ovaska *et al.* 2010
13	12-Sep-10	3	Salmo	Salmo (Darkwoods), N of Porcupine Lake, Selkirk Mountain range	49.3	117.0	1874	Private, protected (Nature Conservancy of Canada)		C. Copley (pers. comm. 2010); inspected by K. Ovaska

The species appears to have a very patchy distribution throughout its range (Brunson and Kevern 1963; Frest and Johannes 1995; Hendricks *et al.* 2007). Most of the occurrences are from Montana, where there are 35 records from 25 sites (Montana Field Guide, undated). The vast majority of these records are recent (post-1998), reflecting increased, targeted search effort over the past decade. There are very few records from BC, Idaho, and Washington. In Idaho, historical records exist from the Bitterroot Mountains and Clearwater National Forest in Idaho County, near the Montana border (Idaho Conservation Data Center 2005). In Washington, the species has been found in the Colville National Forest, Pend Oreille County (Duncan 2008). In 2010, surveys of 172 5 km x 5 km grid cells in the Idaho Panhandle resulted in records of the Magnum Mantleslug from 12 cells in Idaho and two cells in Washington (Lucid *et al.* 2010).

Canadian Range

In Canada, the Magnum Mantleslug is found in southeastern and south-central BC, between latitudes 52 - 49°N and longitudes 115 - 120°W (Figure 3). Its distribution extends from the Canada - US border north to Wells Gray Provincial Park and from near Trail east to Fernie. This distribution encompasses portions of the Rocky Mountains, Columbia Mountains (Purcell, Selkirk and Monashee ranges), and Shuswap Highlands. The species may occur in the Rocky Mountains in extreme southwestern Alberta, but there are no records (see **Search Effort**).

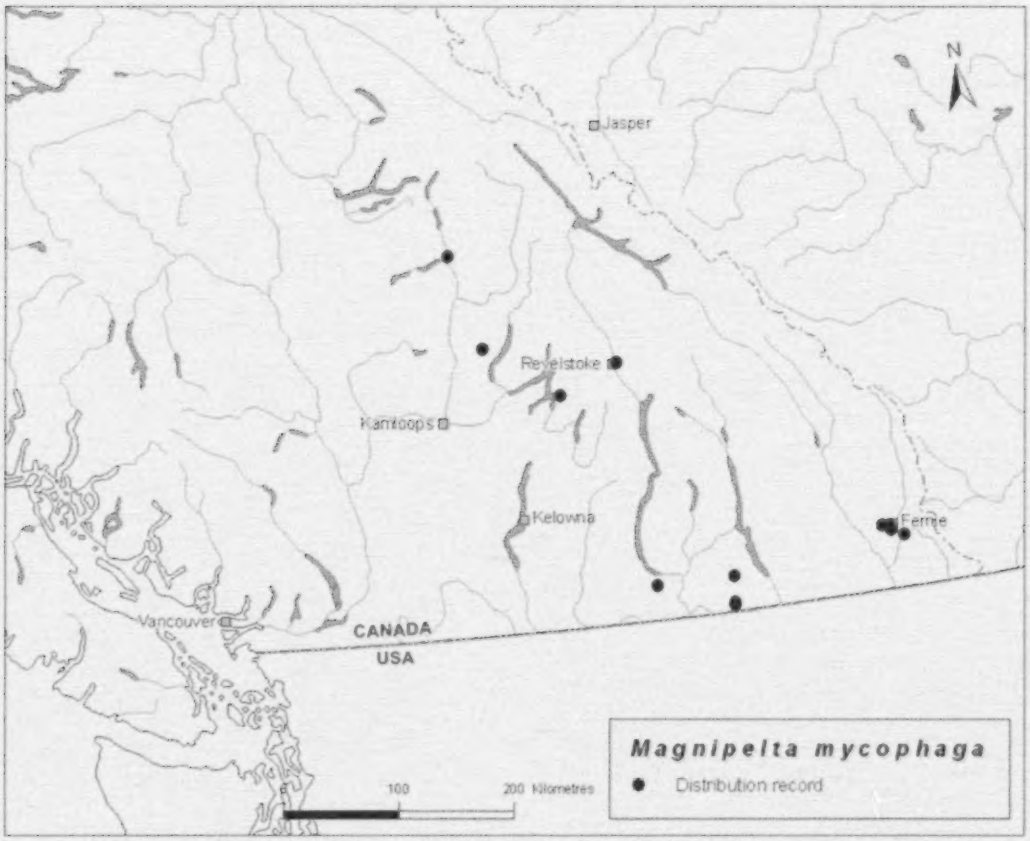


Figure 3. Canadian distribution of Magnum Mantleslug, based on records from 1992 - 2010 (map prepared by Jenny Wu, COSEWIC Secretariat).

As of November 2010, there are 13 records of the species from scattered sites in BC (Table 1). Based on spatial separation, the records are assigned to nine populations and ten sites (Table 1). The Kootenay Pass and Lizard Range populations are each known from two sites (Kootenay Pass: Records 5 and 6 are separated by a highway; Lizard Range; Record 10 is spatially separated from Records 8 and 9 and is under different land tenure). All records are from the past two decades (1992 - 2010); three records, representing 6 slugs, were obtained in 2010 during fieldwork supporting the preparation of this status report. New sites continue to be found with increased survey effort, and it is highly probable that additional, undocumented sites exist.

Extent of Occurrence and Area of Occupancy

Using the minimum convex polygon method, the Extent of Occurrence is 40,813 km². The distribution of the species appears to be very patchy within this large range, possibly reflecting the availability of suitable moist habitats and low dispersal abilities of the slugs. The index of the area of occupancy (IAO), using 2 km x 2 km grids superimposed on the above range, is 48 km². If a 1 km x 1 km grid size is used, which might be appropriate for these slugs that appear to be confined to relatively small habitat patches, the IAO is only 12 km^2. The 48 km^2 IAO calculated using the 2 km x 2 km grids is the discrete IAO value, where each record, except for records 1 and 2, is in a different grid cell (i.e., total of 13 records in 12 cells). Continuous IAO was also calculated but as suitable habitat only exists between records 8, 9, and 10, which are found on the same mountain range (Lizard Range), the value for continuous IAO only increased by 44 km^2, to a total of 92 km^2.

Search Effort

Survey effort in the Kootenay region before the 1990s is poorly documented. Forsyth (1999) found only four brief accounts, from 1905 to 1945, that specifically mentioned terrestrial molluscs from the Columbia Basin of BC. These historical sources contained no records of the Magnum Mantleslug, which remained undescribed until 1953.

Since the early 1990s, surveys have been carried out throughout the species' range in BC, where over 300 sites have been surveyed (Table 2; Figure 4). This effort includes general surveys focusing on forest floor invertebrates, as well as surveys specifically targeting terrestrial gastropods, including the Magnum Mantleslug. In 2010, surveys by Biolinx Environmental Research Ltd. were conducted in support of the preparation of this status report and focused on habitats of the Magnum Mantleslug at known sites and in intervening areas. New sites continue to be found with increasing search effort (e.g., 2 new sites found in 2010). Most of the survey effort has been in the southern portion of the species' distribution (Figure 4), and has concentrated on microsites that contain suitable habitat (see **Habitat Requirements** and **Sampling Effort and Methods**). The range of the species is large and covers rugged, mountainous areas that limit access. However, survey effort has included higher elevation habitats accessible by logging roads or hiking trails. It should also be noted that vast expanses within the overall distribution do not provide suitable habitat, including low elevation valley bottoms with disturbed or dry habitats, high mountain peaks, and drier forest types on mountain slopes.

Table 2. Summary of survey effort for terrestrial gastropods and the Magnum Mantleslug in British Columbia, 1990 - 2010.

Period	Project type	Search effort	Survey type	Magnum Mantleslugs found	Observers	Comments	Source
early to mid-1990s; over 6 - 7 years	Forestry experiment	Experimental forestry sites in 3 areas: Kamloops, Sicamous, Barriere Lakes	Pitfall traps	4 slugs (2 sites)	D. Huggard & coworkers	Intensive sampling for forest floor invertebrates; gastropods not specifically targeted; first records of the species in Canada	D. Huggard (pers. comm. 2009)
late 1990s	Terrestrial gastropod surveys	Unknown	Visual encounter	0 (but see comments)	Heike Reise & John Hutchinson	The Magnum Mantleslug was not found, but subsequently, while on vacation, they found one slug	H. Reise (pers. comm. 2010)
1997 – 2009	Terrestrial gastropod surveys	65 sites	Visual encounter	1 slug	Robert & Tammy Forsyth		R. Forsyth (pers. comm. 2010; RBCM date files & specimens)
1998	*Living Landscapes* Project: Columbia Basin (Royal BC Museum)	31 sites searched (aquatic sites excluded)	Visual encounter	1 slug	Kelly Sendall & Phil Lambert	Surveys for invertebrates, including gastropods	Records from Royal BC Museum database, provided by M. Frederick (pers. comm. 2010)
2007 – 2009	Terrestrial gastropod surveys (Biolinx Environmental Research Ltd.)	127 sites searched for 135 person-hours of intensive searching	Visual encounter	1 slug	Kristiina Ovaska & Lennart Sopuck	Focus of surveys was species deemed to be at risk, including the Magnum Mantleslug	Ovaska and Sopuck 2008, 2009
2009	Invertebrate surveys	23 sites searched	Visual encounter	2 slugs (2 sites)	Claudia Copley, Darren Copley, James Miskelly	Both slugs found were near known sites	C. Copley (pers. comm. 2010); J. Miskelly (pers. comm. 2010)
2010	Invertebrate surveys	9 sites	Visual encounter	3 slugs (1 site)	Claudia Copley, Darren Copley		
2010	Terrestrial gastropod surveys (Biolinx Environmental Research Ltd.)	78 sites searched in 50 areas for 86 person-hours of intensive searching	Visual encounter (day & night)	6 slugs (3 sites)	Lennart Sopuck, Kristiina Ovaska & coworkers	Included dedicated surveys targeting known and potential habitats in the intervening areas for the Magnum Mantleslug; conducted, in part, in support for this status report.	Date file submitted to COSEWIC, Oct 2010 (K. Ovaska & L. Sopuck)

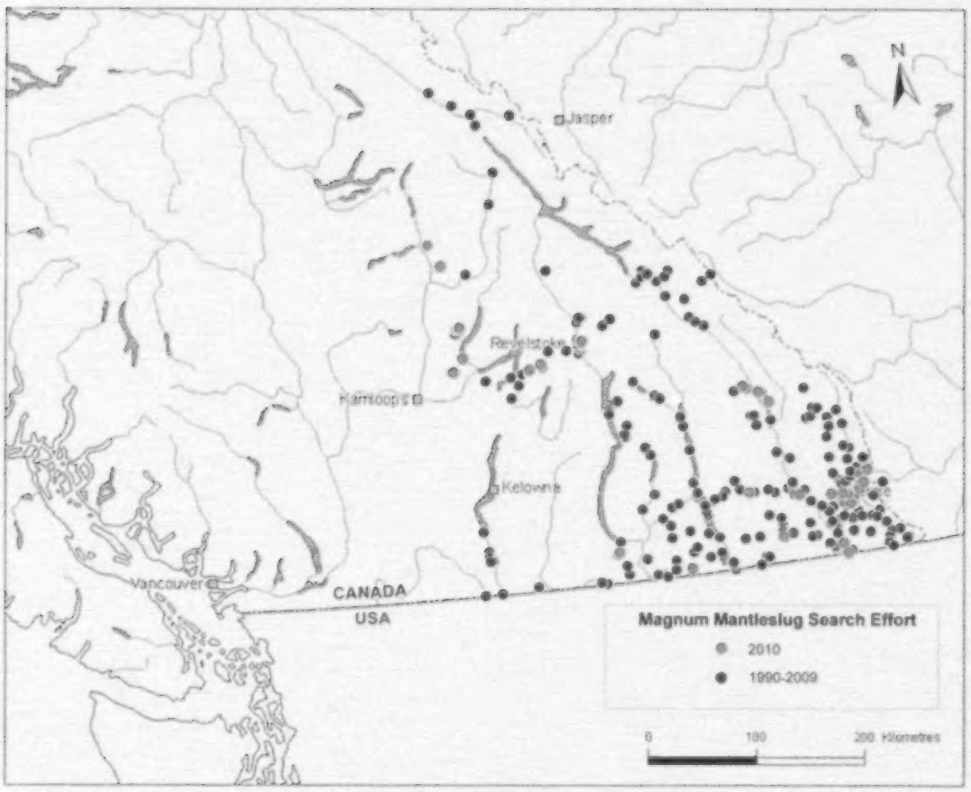


Figure 4. Overview of sites surveyed for terrestrial gastropods within the range of Magnum Mantleslug in southeastern British Columbia. Red symbols – sites surveyed in 2010, as part of the preparation of this status report (map prepared by Lennart Sopuck).

Survey effort for terrestrial gastropods in the Rocky Mountains of Alberta has been limited. Recent efforts consist of surveys by R. Forsyth (pers. comm. 2011) and D. Lepitzki (pers. comm. 2011) in localized areas, including Waterton Lakes National Park. Both researchers noted that most of the Alberta Rocky Mountains are probably too dry for the Magnum Mantleslug but that the species may occur peripherally in the extreme southwest. The species occurs in the Fernie area in BC, and its range may well extend east across the provincial border into Alberta.

These recent searches by Forsyth and Lepitzki, as well as those by Biolinx Environmental Research Ltd., are included in the compilation showing the distribution of recent search effort for terrestrial molluscs in western Canada (Appendix 1). Results from some of these searches have been incorporated into a variety of reports, including COSEWIC status reports and into the database at the Royal British Columbia Museum, but some remain unpublished. Also, this compilation does not include all records from all searchers.

Despite its relatively large body size, the Magnum Mantleslug is difficult to find, probably due to its extremely patchy distribution within the landscape, making it difficult to distinguish rarity from detectability. A study in Montana found that slugs in general had a lower detection probability ($P < 0.6$) than did large snails (P usually > 0.5) and that among slugs of conservation concern included in the study, the Magnum Mantleslug had the lowest detection probability of only 0.2 (Hendricks *et al.* 2007). However, the authors noted that the study was carried out under relatively dry conditions that curtailed surface activity of slugs and made them more difficult to detect than would be the case under wetter conditions. In BC, the species has been found both during drier months (July - August) and under wetter conditions in September (Table 1). Higher elevation habitat can be effectively surveyed only in summer and early fall. There has been no or little survey effort in spring.

The rarity of the Magnum Mantleslug is demonstrated by contrasting successful searches for it and the commonly syntopic Pale-Jumping Slug (*Hemphillia camelus*) by Biolinx Environmental Ltd. using the same search methodologies (Appendix 2). The Pale-Jumping Slug, which can be about 55 mm long, is the most widespread of the three species of *Hemphillia* in BC (Forsyth 2004). NatureServe (2012) status ranks for the Pale-Jumping Slug with the year when last reviewed (in brackets) are: Global status: G4 – apparently secure (2006); United States: N4 – apparently secure (2006); Canada: N3N4 – vulnerable to apparently secure (2004); Idaho: S2 – imperiled; Washington: S3S4 – vulnerable to apparently secure; BC: S3 – vulnerable.

HABITAT

Habitat Requirements

The Magnum Mantleslug occupies mainly coniferous forests at mid- to high elevations and requires cool, moist conditions (Frest and Johannes 1995; Montana Field Guide, undated). It has been recorded from different forest types but appears to be most commonly associated with Engelmann Spruce (*Picea engelmannii*) and Sub-alpine Fir (*Abies lasiocarpa*) stands, based on data from Montana from where most records for the species exist (Hendricks *et al.* 2007). At higher elevations with sparse tree cover, the species is occasionally found in moist, stable talus slides (Pilsbry and Brunson 1954; Hendricks *et al.* 2007). In the US, the slugs are often found in the vicinity of cool springs or creeks fed by snow melt, which contribute to moist microclimates (Brunson and Kevern 1963; Montana Field Guide, undated). The slugs shelter in depressions of moist earth, under decayed, moist logs or pieces of bark, or amidst rocks but actively move on the surface under moist conditions. In reference to US populations, Frest and Johannes (1995) noted that the slugs occur in relatively undisturbed forests where the duff layer is intact; subsequent observations tend to support this suggestion (Hendricks *et al.* 2007; Montana Field Guide, undated).

In BC, the species has been found in the Interior Cedar - Hemlock (ICH) and Engelmann Spruce - Subalpine Fir (ESSF) biogeoclimatic zones (Table 3; BC zone classification by Meidinger and Pojar 1991). The slugs occupied a variety of habitats ranging from avalanche chutes on mountainsides with scattered Engelmann Spruce and Subalpine Fir at higher elevations to relatively dense Douglas-fir (*Pseudotsuga menziesii*) - Western Hemlock (*Tsuga heterophylla*) or Western Redcedar (*Thuja plicata*) dominated forest stands at lower elevations (Figures 5 - 7). The understorey at these sites was highly variable and ranged from dense herbaceous vegetation, as also noted for a productive site for the species in Montana (Brunson and Kevern 1963), to a forest floor virtually devoid of vegetation. Most slugs were associated with coarse woody debris.

Table 3. Habitat at sites where Magnum Mantleslug has been found in British Columbia. BEC: British Columbia biogeoclimatic zone (Meidinger and Pojar 1991); ESSF: Engelmann Spruce – Subalpine Fir; ICH: Interior Cedar-Hemlock.

Record #	Site name	BEC zone/ subzone	Habitat type	Overstorey	Understorey	Substrate	Microhabitat
1-2	East Barrière Lake, ca. 30 km NE of Barrière, Shuswap Highlands	ICHmk2 (near ESSF boundary)	Older (120 yrs old), post-fire coniferous forest	Mostly large Douglas-fir with smaller cedars and some spruce and hemlock; 60% canopy cover	Bare with no shrubs or forbs	5% moss cover, 95% litter cover (dry needles); moderate coarse woody debris (CWD) levels	NA (pitfall traps)
3	Sicamous Creek, ca.7 km ESE of Sicamous, west slope of Monashee Mountains	ESSFwc4 (near ICH boundary)	Old-growth coniferous forest	Subalpine-fir and Spruce; canopy closure 60% for Site 1 and 50% for Site 2 , which were 100 m apart	Site 1: Productive subhydric site with 90% forb cover (oak-fern, valerian, foamflower and *Rubus pedatus*); 40% shrub cover (White Rhododendron, *Vaccinium*); Site 2: Productive mesic site; 80% forbs (*Clintonia*, Oak-fern, *Rubus pedatus*, and foamflower), 30% shrubs (Rhododendron, *Vaccinium membranaceum*)	Site 1: 80% moss and 30% duff cover; CWD typical for ESSF; Site 2: 95% moss and 25% duff cover; sparse CWD	NA (pitfall traps)
4	Near Nancy Greene Park, ca. 20 km W of Castlegar, Monashee Mountains	ICHmw2	Spruce forest near treeline on mid-elevation plateau				
5	Stagleap Provincial Park, NE of Ripple Mountain, Selkirk Mountains (Nelson Range)	ESSFwc4	Forest opening on mountain side	Subalpine-fir; relatively open canopy (from photo)	Dense layer of low shrubs and herbs (from photo)	CWD and rocks (from photo)	On underside of cut log
6	Stagleap Provincial Park, Selkirk Mountains (Nelson Range)	ESSFwc4	Coniferous forest	Open forest of Subalpine-fir	White Rhododendron (dense)		Under log or rock

Record #	Site name	BEC zone/ subzone	Habitat type	Overstorey	Understorey	Substrate	Microhabitat
7	Wells Gray Provincial Park: near Dawson Falls, Shuswap Highlands	ICHdw3	Coniferous forest	Western Redcedar		Abundant CWD	Rotting tree trunk
8	Lizard Range, ca. 4 km SW of Fernie, Rocky Mountain range	ESSFwm	Subalpine mountain slope (90 aspect; 40 slope)	Open forest with scattered Engelmann Spruce & Subalpine-fir (0% canopy closure)	Patch of dense shrubs and herbaceous vegetation by small stream/waterfall; shrubs (80% coverage): Thimbleberry, Elderberry, Douglas Maple, Juniper; herbs (60% coverage): Fringecup, Stinging Nettle, False Solomon's seal, Fireweed	Herbs & grass; Sparse CWD	Active under dense vegetation in splash zone of small waterfall & seepage
9	Lizard Range, ca. 5 km SW of Fernie, Rocky Mountain range	ICHmk4	Second growth coniferous forest	Dense patch of Western Redcedar forest	Bare, virtually no understorey		Under woody debris
10	Lizard Range, ca. 12 km SW of Fernie, Rocky Mountain range	ESSF	Very open subalpine forest in avalanche chute	Opening with Subalpine-fir in surrounding area	Abundant herbs and shrubs (90% coverage); shrubs: *Vaccinium* sp., White Rhododendron, *Ribes* sp., Alder, Mountain Ash, Elderberry; herbs: grass, Indian Hellebore, Meadowrue, Pussytoes, Bluebell, Fireweed, Buttercup	grass/leaves/ferns (thin); little CWD (<5%)	Active on surface within 1 m of intermittent creek/seepage area
11	Mt. Revelstoke, Mount Revelstoke National Park, Rocky Mountain range	ICH	Old growth coniferous forest (148 aspect; 30 slope)	Subalpine-fir, Engelmann Spruce, Western Redcedar, Douglas-fir (60% canopy closure)	Shrubs (60% coverage): Evergreen Huckleberry, Mountain Ash, Blue Huckleberry, Thimbleberry ; herbs (5% coverage): queen's cup. starflowered false Solomon's seal. rattlesnake plantain; oak fern (trace)	needle/ moss (thin & compact); CWD (5%)	Inactive under fairly intact stick ca 10 cm in diameter
12	Morrissey Ridge, near Fernie, Rocky Mountain range	ESSF	Steep, northeast-facing slope in creek valley (48 aspect; 52 slope)	Almost no trees on slope, but trees occur on lip of canyon and opposite bank (Engelmann Spruce, Subalpine-fir, Douglas-fir)	Abundant shrubs, herbs and ferns; shrubs (70% coverage): alder, thimbleberry, *Ribes* sp., Elderberry; herbs (50% coverage): grass, Stinging Nettle, Meadow-rue, False Solomon's Seal, Indian Hellebore; lady fern, wood fern	Very moist litter (leaf/moss); , some CWD (small logs) on slope (7% coverage)	2 slugs together under log buried deep in moist rotten wood next to bark layer on bottom; 2 slugs about 30 cm apart under log, attached to log underside
13	Salmo (Darkwoods), N of Porcupine Lake, Selkirk Mountain range	ESSF	Rocky/talus scree hillside	Engelmann Spruce, Subalpine Fir, and Larch			Under rocks or downed wood

Very moist conditions seem to be a common denominator to all microsites where the species has been found. At one site, a slug was actively moving under abundant herbaceous vegetation within the splash zone of a small waterfall (Record 8 in Table 3; Figure 5). At this site, the creek and waterfall created a narrow (< 1 m wide) riparian zone where the vegetation was wet with water droplets even on a hot (30°C) July day. At another site, four individuals were found in a seepage area on a steep, northeast-facing rocky slope in a small creek valley (Record 12 in Table 3; Figure 6). The steepness of the slope and northern aspect resulted in a cool, moist habitat shaded from direct sunlight for most of the day. The patch of suitable habitat extended for only 30 - 50 m along one side of the creek.

Figure 5. Magnum Mantleslug habitat on Lizard Range, near Fernie, BC. The species was found in the seepage zone of a cascading creek supporting dense shrubs and herbs (red circle and insert) (photos by Lennart Sopuck & Kristiina Ovaska).

Figure 6. Magnum Mantleslug habitat near Morrissey Ridge east of Fernie, BC. The species was found in shaded, moist, northeast facing slope (right) (photo by Lennart Sopuck).

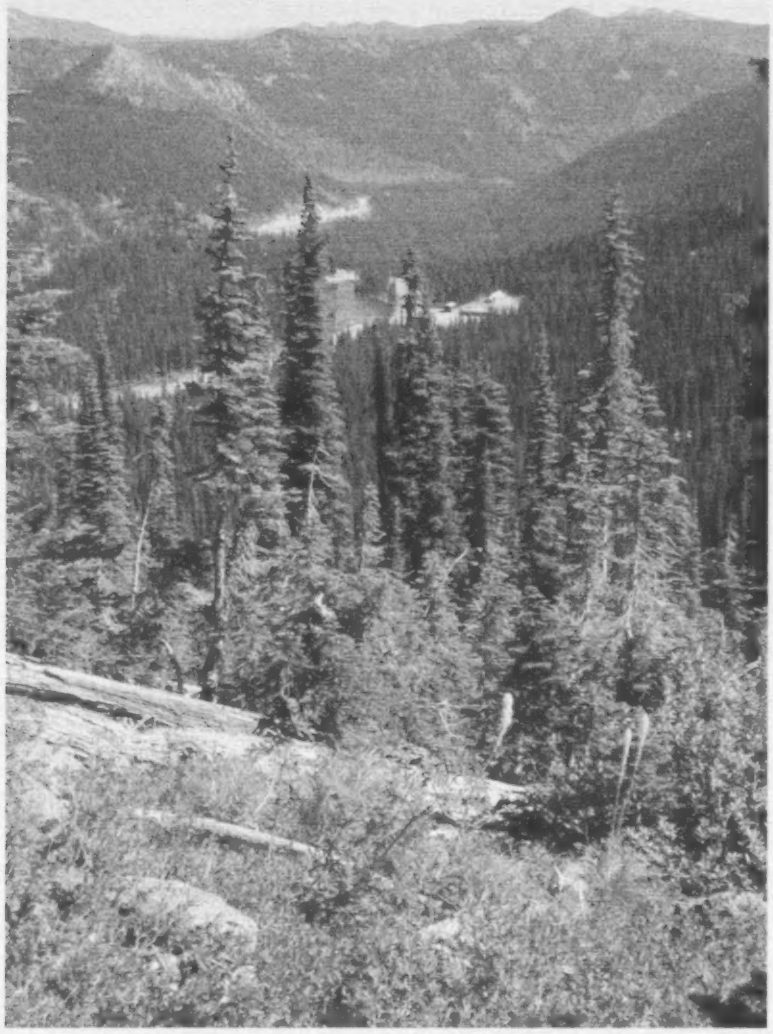


Figure 7. Magnum Mantleslug habitat near Kootenay Pass, BC. (photo by Robert Forsyth).

Moist, cool microhabitat conditions with adequate cover from predators and adverse environmental conditions probably exert an overriding influence on habitat use by the slugs, and these requirements may be met in various ways. In harsh environments near the tree line, the slugs may be tied to the immediate vicinity of springs and seepages and to the herbaceous fringe around these sites, whereas in more continuous old forest, shaded conditions under the canopy and moist coarse woody debris may provide suitable refuges. Small gaps characteristic of older forests support herbaceous vegetation that may be important for foraging.

Habitat Trends

Prior to 1960, southeastern and south-central BC was relatively sparsely populated, and habitat loss or degradation was limited primarily to valley bottoms and other low elevation areas. From 1960 to present, the range of the Magnum Mantleslug has become increasingly fragmented mainly due to logging, agriculture, ranching, mining, hydro development, and land conversions for residential areas. From 2008 - 2036, the human population is expected to increase by 11% in the Kootenay Region and 32% in the Thompson-Okanagan Region (BC Stats 2010). The greatest contributor to habitat fragmentation is logging. Since the 1970s, about half of the species' range has been heavily fragmented by logging (Austin *et al.* 2008). Low to mid-elevation forests, including the Interior Douglas-fir, Interior Cedar–Hemlock, and Montane Spruce biogeoclimatic zones are most impacted, whereas portions of the higher elevation Engelmann Spruce–Sub-alpine Fir zone are still relatively intact. Recent increase in Mountain Pine Beetle (*Dendroctonus ponderosae*) infestations, in combination with salvage logging and severe wildfires, has resulted in a rapid loss of forest cover over the past two decades, and this trend is expected to continue. The area of British Columbia's forests impacted by the Mountain Pine Beetle is expected to increase from 19% in 2006 to 32% by 2018 (Austin *et al.* 2008), but most of the damage is in drier forests with a large component of pine. The effects of the Pine Beetle on the species' range are greatest in the south-central part of the province (Austin *et al.* 2008), but logging is expanding southeastward into the range of the Magnum Mantleslug.

Another major contributor to habitat degradation and fragmentation is ranching. Grazing by livestock is widespread within the species' range, even at higher elevations, as livestock are allowed to roam free over vast areas of forested habitat. The practice of allowing grazing tenures on provincial Crown land is widespread in British Columbia (Austin *et al.* 2008).

The network of transportation/utility corridors and hydroelectric reservoirs has contributed to fragmentation of the species' range, especially over the past 50 years (Austin *et al.* 2008). Due to the mountainous terrain, these developments occur mainly in valley bottoms, possibly impeding gene flow.

Mining is becoming an increasingly important contributor to habitat degradation and fragmentation over the species' range. In particular, coal strip mining in the southeastern part of the province has resulted in the loss of large areas of forested habitat, and these activities are expected to expand in the future (Mining - technology.com 2010).

Although the range of the species is becoming increasingly fragmented, considerable areas of mid- to high elevation forests are still intact due to a network of protected areas and inaccessible terrain. Overall, in the ESSF and ICH zones in BC, 60% and 39%, respectively, was older than 140 years in 2008 (BC Ministry of Forests, Mines and Lands 2010). Examination of orthophotos in GoogleEarth over the species' Canadian range similarly revealed large areas of intact forest at higher elevations. These relatively undisturbed areas are expected to persist over the foreseeable future. However, habitats at low to mid-elevations will continue to be fragmented and will contribute to the increasing isolation of populations.

BIOLOGY

Life Cycle and Reproduction

Very little is known of the life cycle of the Magnum Mantleslug, and there is virtually no information for BC. The species is hermaphroditic, possessing both female and male reproductive organs (Pilsbry and Brunson 1954; Webb and Russell 1977). However, like most terrestrial gastropods, individuals probably exchange sperm; there is no evidence of self-fertilization.

Copulation and egg-laying probably occurs in the spring and/or in the autumn. A mating pair of slugs was found in May in Montana (Montana Field Guide, undated). Pilsbry and Brunson (1954) found the smallest individuals, 14 mm in length, in April - May at a high density site in Montana and suggested that egg-laying had occurred earlier in the season. In BC, most individuals found have been adults. A hatchling-sized slug (9.5 mm long, when preserved in ethanol) was found in September; another small (17 mm long when preserved), apparently juvenile slug was found at the same time (Record 13 in Table 1). Duncan (2008) suggested that eggs may be laid in the fall and then hatch the following spring soon after snow melt, as noted for other slugs in high elevation habitats. There are no records of eggs or egg-laying sites from Canada or the US. Age of sexual maturity is unknown. The presence of adult-sized individuals in the spring indicates that the slugs live multiple years. The generation time is unknown but is probably around 1 or more years, as adult-sized slugs that have overwintered have been found in spring in Montana (Pilsbry and Brunson 1954; Brunson and Kevern 1963). In contrast, Duncan (2008) suggested that the slugs may reproduce in the first fall or spring after hatching, but provided no evidence.

Seasonal Activity

The slugs become active early in the spring when there may still be snow on the ground (Brunson and Kevern 1963). Seasonal activity peaks in the spring and again in the autumn when conditions are cool and moist, based on data from Montana (Brunson and Kevern 1963; Montana Field Guide, undated). The slugs reduce their surface activity and probably retreat deep into refuges during dry periods in the summer and cold periods in the winter. In BC, the species has been found in July (1 slug), August (6 slugs), and September (10 slugs) (Table 1); the small number of observations and uneven survey effort precludes meaningful inferences about seasonal activity.

Diet

These slugs probably feed on green and decaying vegetable matter and on fungi, similar to other arionids, but little specific information is available. The type specimen was feeding on a large fungus when found (Pilsbry 1953). Pilsbry and Brunson (1954) noted that in captivity, the slugs, although reluctant, fed on head lettuce. In Montana, Brunson and Kevern (1963) noted the green colour of feces and suggested that the species has a vegetarian diet of green plants or moss.

Behaviour

The slugs are probably mainly nocturnal or crepuscular but can be found active during the day under very moist conditions (Brunson and Kevern 1963; Ovaska and Sopuck 2008). In Montana, Brunson and Kevern (1963) found slugs on the surface and climbing in lower foliage on cool moist days, whereas during warm, dryer periods they were found exclusively in refuges.

Pilsbry and Brunson (1954) reported that the slugs exhibit an unusual behaviour in response to disturbance: "If poked with a probe or finger, the muscles of the animal visibly tighten and the mantle is spread wing-fashion. The degree of spreading apparently is dependent upon the amount of pressure applied. This spreading is so extreme at times that the anterior portion of the mantle may be curled back". This behaviour probably functions as an antipredator tactic, perhaps startling the potential predator or exaggerating the body size, making the slug appear too large to swallow.

Physiology and Adaptability

Several authors have noted the affinity of the species to cool and moist microhabitats (Pilsbry and Brunson 1954; Brunson and Kevern 1963; Frest and Johannes 1995; Hendricks *et al.* 2007; Duncan 2008). Brunson and Kevern (1963) reported that the slugs appear to prefer substrate temperatures of 11.7- 15.5°C (reported as 53 - 60°F). Their requirements for cool, moist microhabitats probably limit their distribution within the landscape and increase their vulnerability to human activities that alter hydrology or forest floor microclimates.

Dispersal and Migration

Virtually nothing is known of dispersal or migration of this species. In Montana, Brunson and Kevern (1963) recorded the speed of one slug as 14 inches (35.6 cm)/1 hour and repeatedly found what appeared to be the same slugs under the same cover-objects. They suggested that individual slugs might not move much or have a tendency to return to the same place. However, they also noted that the slugs slightly shifted their distribution within the habitat patch from spring to summer, suggesting seasonal dispersal from overwintering and/or spring foraging areas.

Land snails in general are relatively sedentary and have poor dispersal abilities if not aided by humans or transported by other passive means, such as wind or water (review in Cordeiro 2004). No passive means of transport are known for the Magnum Mantleslug. It is possible that the slugs may inadvertently attach to fur of mammals, such as bears.

Interspecific Interactions

No specific data are available, but it is possible that the Magnum Mantleslug disperses seeds of forest floor plants and/or fungal spores similar to other forest-dwelling arionid slugs (Gervais *et al.* 1998; McGraw *et al.* 2002). At present, introduced gastropods are largely absent from the mid- to high elevation forests inhabited by this species. As access continues to increase with expanding logging and recreational and other human activities, introduced gastropods are expected to spread and may compete with this species for food or refuges. Habitat shifts associated with climate change may also bring the species in contact with native and introduced predators and competitors (see **THREATS AND LIMITING FACTORS**).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Surveys have focused on detecting this difficult-to-find species, rather than obtaining abundance estimates (see **DISTRIBUTION: Search Effort**). Most surveys have consisted of visual searches of the forest floor and litter layer to locate gastropods (Table 2). Pitfall trapping was deployed as part of broader invertebrate sampling at three sites, including two sites where the species was found (D. Huggard pers. comm. 2009). Searches by Biolinx Environmental Research Ltd. were timed to provide an index of survey effort (Table 2). This visual encounter method does not quantify the area searched, but allows the searchers to concentrate on suitable microhabitats and resulted in 221 person-hours of intensive searches at 205 sites. The surveys consisted of observers walking through the habitat of interest and examining important microhabitat features for gastropods, such as decaying logs, piles of bark, stumps, rocks, or other cover-objects or moist refuges, and accumulations of moist leaf litter. Most searches were carried out during daylight hours, but four surveys in 2010 were

conducted on wet nights. Night surveys consisted of observers walking along trails with powerful flashlights (3 surveys) or slowly driving with fog lights on alongside roads that traversed suitable habitat (2 surveys), scanning the ground or road surface for slugs.

Abundance and Fragmentation

The total Canadian population is deemed to consist of nine scattered and isolated populations (Table 1). With the exception of the Fernie area, each dot or group of dots in Figure 3 represents a population. The Fernie area was deemed to contain two populations based on discontinuities in habitat: one population on Lizard Range and another on Morrissey Ridge. No estimates of population sizes are available. Based on habitat condition and/or records with multiple specimens or from more than one site, four populations (Lizard Range, Stagleap, Mt. Revelstoke, Salmo) may support larger populations. One population (Morrissey) is within a small, isolated habitat patch, and its long-term viability is questionable. Three (Barrière, Sicamous, Monashee) are known from only older records within subsequently modified landscapes. The remaining population is known from a single record in a provincial park (Wells Gray) where suitable moist habitats appear to be limited. Whether the total population is severely fragmented (i.e., 50% of individuals are in isolated habitat patches that might not support viable populations) is possible but cannot be assessed accurately due to data limitations.

There are 13 records of the species from BC, representing a total of only 15 individuals (Tables 1, 2). Most records are of single slugs. At one site (Record 12), four individuals were found in 3 person-hours of searching within an approximately 30 m x 10 m area, which represented most of the habitat deemed suitable. At three other sites where search time is available, one slug was found in 1.3 (Record 11), 1.5 (Record 10), and 1.0 (Record 8) person-hours of searching an approximately 30 m x 30 m area per site.

In Montana, the species is also patchily distributed (Brunson and Kevern 1963; Montana Field Guide, undated). As in BC, most observations represent only 1 - 2 individuals (Montana Field Guide, undated), but concentrations of slugs have been found at a few sites, including a historical site near Deer Creek in northwestern Montana. Brunson and Kevern (1963) visited this site repeatedly in the 1950s and found up to 87 individuals within a 15 - 20 foot (4.6 - 6.1 m) strip along a 440 yard (402 m) stretch of riparian habitat along the river. No slugs were found in the surrounding area beyond this patch. In another habitat patch 5.6 km south of the above site, P. Hendricks found 32 slugs within a 30 m x 30 m area, which was searched for 1 hour in 2005 (Montana Field Guide, undated).

Fluctuations and Trends

There is no information on fluctuations and trends of populations in BC. All records are relatively recent (1992 - 2010), and new sites continue to be found with increasing search effort. All six sites where the species had been found previously were visited in 2010 by Biolinx Environmental Research Ltd.; the species was found only near one of the sites, as well as at two new sites in the intervening areas. The species was not found at any of the three sites with older (1992 - 1998) records, but repeated surveys are required to establish absence. Given the species' patchy distribution across the landscape, poor dispersal ability, and scattered distribution of suitable moist habitat patches, it is highly probable that sites and populations have been lost historically and continue to be lost as a result of human modifications of the habitat. In Montana, the population at the historical Deer Creek site has declined or disappeared, probably as a result of habitat disturbance; however, the species continues to persist in the general area (Montana Field Guide, undated).

Rescue Effect

Rescue from the United States is possible but unlikely over the short term, given the poor dispersal ability and patchy distribution of the slugs. There are several records of the species from near (within 10 km) the Canada - US border in northwestern Montana and the Idaho Panhandle (Montana Field Guide, undated; Lucid *et al.* 2010). Dispersal could occur through the Flathead Valley (east of Koocanusa Lake and the Continental Divide) along the lower, western slopes of the Rocky Mountains, where the habitat is more or less continuous. The nearest Canadian populations are on the Lizard Range and near Morrissey Ridge, only about 45 - 50 km from the international border. Another possible route across the border is along the north - south oriented Selkirk Mountain Range that extends from BC to the Idaho Panhandle and supports the Stagleap and Salmo populations. There is a recent record of the species within 5 km of the international border in the Idaho Panhandle (Lucid *et al.* 2010). Both of the above routes have probably allowed the species to expand its distribution into Canada post-glacially.

THREATS AND LIMITING FACTORS

Limiting Factors

The species' distribution in Canada is probably limited by naturally patchy habitats: suitable moist coniferous forests are confined to mid- to high elevations and are intersected by vast expanses of relatively dry pine forests, wide unsuitable valleys and plateaus, high elevation mountain peaks, and dry, unstable talus slopes and rock slides on mountain sides. Furthermore, within suitable forest types, cool, moist microsites preferred by the slugs are patchily distributed. Superimposed on this pattern, human developments and activities have further fragmented and altered habitats and created often insurmountable barriers to movements and gene flow.

IUCN Threats Calculator

To assess threats across the entire Canadian distribution of the Magnum Mantleslug, including possible undocumented sites, the IUCN threats calculator (Master *et al.* 2009) was used (Table 5). For this method, the scope, severity, and timing are scored for each threat category; the overall impact of the threats is then computed from these ratings. "Biological resource use", with "logging & wood harvesting" the only contributor to this threat category, had the highest overall impact, which was rated as medium; "Climate change & severe weather" had the impact rating of medium-low. Impacts from other threats were rated as low. The overall threat impact was scored as high, based on 1 - 2 medium and 6 - 7 low impact ratings for the main threat categories. Headings in the following narrative correspond to categories or subcategories of the threats calculator, in order of potential importance.

Logging & Wood Harvesting (impact: medium)

The Magnum Mantleslug depends on moist microsites that are sensitive to logging and associated drying of the forest floor due to opening of the canopy, edge effects, and alteration of hydrology; direct disturbance of these microsites during logging is also a concern. Logging is prevalent throughout the species' Canadian range (see **Habitat Trends**). Forest in the vicinity of six of ten sites (nearby sub-sites combined for Lizard Range and Stagleap for analysis) has been logged recently (Table 4; Figure 8), and logging continues to threaten slugs at five of these sites; the remaining site (Stagleap) is within a provincial park where there is no logging, but logging is prevalent immediately to the southeast. Logging has the potential to disturb site hydrology and temperature regimes and alter microclimates and slug habitats. Regeneration of logged habitats is expected to be slow, reflecting slow tree growth in cool, mid- to high elevation areas inhabited by the slugs.

Table 4. Habitat disturbance at sites where Magnum Mantleslug has been found in British Columbia. % refers to approximate percentage of land subjected to different land uses within about 1 km and 10 km radius area around slug records, as determined visually from Google Earth orthophotos.

Record #	Site name	Logging (%)		Agricultural/ residential (%)		Recreational dev. (%)		Major roads & railways		Other		Comments
		1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	
1-2	East Barrière Lake, ca. 30 km NE of Barrière, Shuswap Highlands	50	80	0	5	0	5			Logging & skid roads	Logging & skid roads	Patchwork of recent logging throughout much of area (clearcut & selective); evidence of patches of old fire or old logging in old growth forest where the species was found; agricultural clearings & recreational area with housing along lakeside
3	Sicamous Creek, ca 7 km ESE of Sicamous, W slope of Monashee Mountains	20	50	0	10	0	0		HWY 1	Logging roads	Logging roads	Logging consists of patchwork of different-sized clearings, mostly small but some large; logging roads through much of the area; land clearing for residential development and agriculture along valley bottom along HWY 1 and around townsite of Sicamous
4	Near Nancy Greene Park, Monashee Mountains, ca. 20 km W of Castlegar	50	60	0	0	0	0	HWYs 3 & 3B	HWYs 3 & 3B	Logging roads	Logging roads	Very large clearcuts, from probably from 1970s to present, some are very recent; provincial park is very small (about 1% of 10 km radius area
5-6	Stagleap Provincial Park, Selkirk Mountains (Nelson Range)	20	20	0	<1	<1	0	HWY 3	HWY 3	Trails; power/ pipe line	Logging roads; power/ pipe line	Mostly undisturbed forest & high elevation ridges within park; major HWY (#3) intersects habitat and probably acts as barrier to movements; patchwork of logging to the SE with relatively small clearcuts
7	Wells Gray Provincial Park: near Dawson Falls, Shuswap Highlands	0	0	0	5	5	1	Park access road		Trails, some heavily used; campgro und	Trails; golf course & resort; few houses/ ranches	Forest relatively intact but possibly constitutes marginal habitat at northern extremity of the distribution; heavy recreational use along hiking trails near slug location; infrastructure includes campground; some ranching and residential properties along access road to park
8-9	Lizard Range, ca. 4 km SW of Fernie, Rocky Mountain range	0	20	0	20	25	5	No	HWY 3; railway	Numero us ski runs & trails	Logging & residential roads; powerline	Ski runs on mountain slope (cleared areas with patches of forest); intensive infrastructure development at base of hill; Elk Valley ca. 2 km away is heavily developed; little disturbance at high elevations, but lower- to mid-elevation slopes have extensive clearcut logging
10	Lizard Range, ca. 12 km SW of Fernie	5	10	0	10	2	5	No	HWY 3; railway	Skid trails & trails	Access & logging roads; power line	Recreational trails for hiking & cat skiing near slug location
12	Morrissey Ridge, near Fernie	60	50	0	5	0	0	NA	HWY 3; railway	Logging roads	Power transmissi on or pipeline (wide corridor); logging roads	Recent and young regenerating large clearcuts, especially to the south; logging roads crisscross the area; accessible to ATVs & recreational vehicles
11	Mt Revelstoke, Mount Revelstoke National Park	0	30	0	25	1	2	Park road (paved)	HWYs 1 & 23; National Park road		Hydro-electric dev. (10%); logging roads	Slug location surrounded by uncut forest
13	Salmo (Darkwoods)	40	50	0	0	0	0	No	No	Logging roads	Logging roads	Recent logging and young regenerating forest with numerous logging roads throughout lower elevations; rugged and largely bare mountain sides (e.g., to the east within 1 km radius) are mostly not suitable habitat

Figure 8. Example of logging in Magnum Mantleslug habitat. The pin denotes a site where the species was found southeast of Fernie, BC.

Climate Change (impact: medium - low)

Shifts in habitats and ecosystems are expected to occur as a result of climate change, but much uncertainty exists both on the speed and type of these changes. Within the species' range in BC, a slight but persistent increase in temperature has been recorded in winter, spring, and summer over a 30-year period (1971 - 2000), and these trends are expected to continue into the future (Austin *et al.* 2008). Species inhabiting higher elevation habitats, such as the Magnum Mantleslug, might be particularly vulnerable, as even small changes can result in habitat shifts along altitudinal gradients. Based on survey data coupled with modelling, Müller *et al.* (2009) found that terrestrial gastropods inhabiting higher altitudes of relatively low forested mountain ranges in Bavaria in Central Europe were particularly vulnerable to climate change. Overall gastropod diversity in higher elevation forests was predicted to increase, but ranges of higher elevation inhabitants, exemplified by *Semilimax kotulae* (family Vitrinidae), were predicted to shrink, eventually leading to extirpation. This species occurs in cool, humid, and shady mountain habitats, usually below the treeline; populations at lower elevations are occasionally found in pockets of cold air below scree slopes (Müller *et al.* 2009). The affinity of the Magnum Mantleslug to higher elevation forests and cool, moist microhabitats suggests that it might be similarly vulnerable to the encroachment of lower elevation forest types farther up mountainsides. Although there

might be a corresponding shift in higher elevation forest as trees will encroach on alpine tundra, it is probable that the shifts are unlikely to compensate for loss of habitat and ecosystem changes.

Housing & Urban Areas (impact: low)

Urbanization is expanding within the species' range and may be a threat in localized areas (see **Habitat Trends**). No known occupied sites are threatened by housing and urban developments.

Tourism & Recreation Areas (impact: low)

Development of new recreational sites or expansion of existing sites, including accommodation and facilities, such as new ski runs, is ongoing within the species' range. These mountain developments have a great potential to overlap with habitats of the Magnum Mantleslug. Three of the ten known sites are within resorts (Table 1); it is unknown whether expansions are likely in the future. A large expansion of a mountain resort is in progress in suitable slug habitat approximately 40 km south of the Barrière site.

Livestock Farming & Ranching (impact: low)

Grazing by free-ranging cattle is prevalent throughout the species' Canadian range and can contribute to deterioration of habitat conditions on the forest floor. Cattle grazing is less intensive in higher elevation, moist forests inhabited by the Magnum Mantleslug, resulting in a low impact rating.

Mining & Quarrying (impact: low)

Mining and quarrying occur throughout the species' range (see **Habitat Trends**), and have the potential to destroy slug habitats in localized areas. No known occupied sites are threatened by mining, However, an area of extensive strip-mining for coal within potential habitat for the species occurs 22 - 30 km northeast of occupied sites near Fernie and Morrissey Ridge.

Transportation & Service Corridors (impact: low)

The Canadian range of the species is heavily fragmented by roads, and logging roads crisscross forest habitats in many areas. Major roads continue to form barriers to movements, but their effects on populations are probably mainly historical. Habitat loss and fragmentation caused by new logging roads are probably more important at present, but the degree to which they constrain movements and affect population structure is unknown.

Recreational Activities (impact: low)

Intensive recreational use and infrastructure developments, including ski runs, occur at one site (Lizard Range); at another site (Wells Gray), the species occurs in a forest patch adjacent to a heavily used trail near a popular tourist attraction. In these areas, heavy recreational use could result in soil compaction and damage to understorey vegetation, posing threats to slug habitats. Hiking and light recreational use is expected to have little impact on the species. Logging roads have increased public access to the backcountry, including off-road vehicles that compact soil and can destroy habitat patches used by the slugs.

Fire and Fire Suppression (impact: low)

Terrestrial gastropods are potentially vulnerable to wildfires because of their limited dispersal ability and because they are often tied to habitat patches with specific vegetation or moisture characteristics, which constrain recolonization of burned areas (Santos *et al.* 2009). In BC, the length of the fire season and size of burned areas have increased over the past few decades, and these trends are predicted to continue with climate change (Austin *et al.* 2008). Fires and the broadcast of fire retardants into the environment are identified as a potential threat to the species in Montana, although their effects on this and other species of terrestrial gastropods remain largely unknown (Montana Field Guide, undated). In Mediterranean ecosystems, a large fire had reduced the species richness of terrestrial gastropods and caused a shift in species composition from woodland to open area species, when sampled 4 years later (Santos *et al.* 2009). In southwestern Oregon, both the distribution and abundance of four species of terrestrial gastropods studied were reduced after low-intensity prescribed fires (Duncan 2005). The effects were more severe on snails than on slugs (e.g., Blue-grey Taildropper, *Prophysaon coeruleum*), but slugs were not found at over a quarter of the sites that supported them during pre-fire surveys. The author suggested that at sites with continued persistence, slugs survived in deep fissures in coarse rock substrate or other underground refuges and suggested that the distribution of microhabitats that allow for vertical movements is important for the long-term viability of slug populations within the landscape.

Invasive and non-native alien species (impact: unknown)

With climate change, there is an increased potential for invasive species, including introduced and native lower elevation terrestrial gastropods, to spread into Magnum Mantleslug habitats. At one site where the Magnum Mantleslug was found at 1403 m (Mt. Revelstoke) in September 2010, a night drive from 1575 m to 609 m suggested a marked transition in slug species with elevation; introduced species (*Arion rufus*, *Limax maximus*), *Ariolimax columbianus* (widespread along BC coast but not previously recorded from the Kootenay Region), and *Prophysaon andersonii* were found only below 800 m, whereas *Hemphillia camelus* was found at a range of elevations up to 1145 m (Ovaska and Sopuck data files for this report). *Hemphillia camelus* is commonly syntopic with the Magnum Mantleslug, whereas the other species mentioned are

associated with lower elevation forest types, including mixed-wood stands, and have not been found with this species. Wide-scale habitat modification by the Mountain Pine Beetle may also pose problems (see **Habitat Trends**).

Number of Locations

The number of COSEWIC locations, based on threats to known sites, ranges from 10 - 12 for wildfire, logging, and recreational development and activities combined (see Table 5 for number of locations per individual threat category). Additional occupied sites probably exist over the species' wide Canadian distribution, which would increase the number of locations from these threats. The number of locations could be lower for climate change, but there is high uncertainty associated with the impacts and timing. For the threat of climate change (through increase in prolonged seasonal droughts and associated changes in hydrology and micro-sites), the number of locations is 9: each mountain range with records of the species is considered a separate location with all the mountains within a range being affected in a similar way. If new sites occupied by the slug are discovered within the currently known occupied mountain ranges, the number of locations under climate change would not increase; however, if new occupied sites are discovered on different mountain ranges, the number of locations under climate change could increase from the putative 9.

Table 5. Threat assessment for Magnum Mantleslug, using IUCN threat categories and calculator. Only categories with non-zero ratings are shown.

Threat	Impact (calculated)	Scope[1]	Severity[2]	Timing[3]	Comments[4]	No. of locations
Residential & commercial development	Low	Small	Moderate	High		
Housing & urban areas	Low	Small	Serious	High	Mostly historical in lower elevations; current scope small	Unknown
Tourism & recreation areas	Low	Small	Moderate	High	Ski and recreational areas expanding in slug habitats	Unknown
Agriculture & aquaculture	Low	Restricted	Moderate	High		
Livestock farming & ranching	Low	Restricted	Moderate	High	Free-ranging cattle throughout the species' range but mostly at lower elevations	Unknown
Energy production & mining	Low	Small	Moderate	High		
Mining & quarrying	Low	Small	Moderate	High	Occurs throughout the species' range, including coal strip mining; no known sites are presently threatened	Unknown
Transportation & service corridors	Low	Restricted	Moderate	High		

Threat	Impact (calculated)	Scope[1]	Severity[2]	Timing[3]	Comments[4]	No. of locations
Roads & railroads	Low	Restricted	Moderate	High	Barriers to movements, leading to habitat fragmentation and isolation of populations; impacts difficult to assess accurately	Unknown
Utility & service lines	Low	Restricted	Slight	High		
Biological resource use	Medium	Large	Moderate	High		
Logging & wood harvesting	Medium	Large	Moderate	High	Continues through much of the species' range, including higher elevations	5 (known sites)
Human intrusions & disturbance	Low	Large-restricted	Slight	High		
Recreational activities	Low	Large-restricted	Slight	High	Access to backcountry increased through logging roads that crisscross many areas; ATVs & recreational vehicles can seriously degrade habitat; hiking trails have slight impact	Unknown; 6 known sites are within recreational areas
Natural system modifications	Low	Restricted	Moderate	High		
Fire & fire suppression	Low	Restricted	Moderate	High	Wildfires and the broadcast of fire retardants into the environment are identified as a potential threat to the species in Montana. Fire frequency is increasing in BC as result of droughts associated with climate change and past fire suppression practices; effects depend on the intensity & areal extent of fires.	12 for known sites
Invasive & other problematic species & genes	Unknown	Large	Unknown	High		
Invasive non-native/alien species	Unknown	Large	Unknown	High	Potential for introducing or spreading invasive gastropods is high with increased human access to backcountry habitats & with habitat shifts with climate change; threats from competition/predation possible but unknown; Mountain Pine Beetle outbreaks are changing forest habitats throughout much of the species' Canadian range.	Unknown
Climate change & severe weather	Medium-low	Pervasive	Moderate - Slight	High		

Threat	Impact (calculated)	Scope[1]	Severity[2]	Timing[3]	Comments[4]	No. of locations
Habitat shifting & alteration	Medium - Low	Pervasive	Moderate - Slight	High	Changes to hydrology & seasonal moisture regimes; encroachment of lower elevation forests and associated ecosystems upwards along altitudinal gradients	9 if each mountain range is considered a separate location and subjected to similar climate-related changes
Droughts	Low	Pervasive	Slight	High		As above

[1]Small, restricted, large, pervasive

[2]Slight, moderate, extreme, serious

[3]Insignificant, low, moderate, high

[4]For all threats, see text (THREATS AND LIMITING FACTORS) for further rationale and explanation

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Currently, the species has no official protection or status under the federal *Species at Risk Act*, BC *Wildlife Act*, or other legislation.

Non-Legal Status and Ranks

According to NatureServe (2010), the global, national and subnational status ranks of the Magnum Mantleslug are as follows (year when last reviewed): Global status: G3 - vulnerable (2006); United States: N3 - vulnerable (2004); Canada: N2N3 - imperiled to vulnerable (2004); Idaho: SNR - not assessed; Montana: S1S3 - critically imperiled to vulnerable; Washington: S2 - imperiled; British Columbia: S2S3 - imperiled to vulnerable. In addition, the species is on the provincial blue list of species at risk (currently under reassessment). A rank of S2S3 is listed on the Montana government web site (Montana Field Guide, undated).

Habitat Protection and Ownership

The species has been recorded from Mount Revelstoke National Park and two provincial parks, Wells Gray and Stagleap (Table 1). One site is within a protected area owned by the Nature Conservancy of Canada. Populations in these protected areas are not necessarily safe, as habitats could be inadvertently destroyed, damaged, disturbed or altered as a result of infrastructure or trail development or visitor activities. Typically within parks, watercourses are maintained in their original channels during trail work and visitors are directed to keep their footsteps to the hardened trail. Three sites are within BC Crown Lands used for forestry and one site is on private forestry lands. The remaining two sites are on private resort/recreational lands.

As a provincially blue-listed species impacted by forest and range practices, the species is potentially eligible for management under the Identified Wildlife Management Strategy of the BC *Forest and Range Practices Act*. However, it is not listed as identified wildlife at present, and hence no management guidelines are available.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Robert Forsyth generously provided data and shared unpublished distribution records. He also provided valuable comments and suggestions on an earlier version of this report. Dave Huggard, Claudia Copley, James Miskelly, and Heike Reise kindly provided details of their records of the species from British Columbia. Paul Hendricks provided information and distribution records for the species in Montana. Ian Adams and Kari Stuart-Smith provided helpful information on potential habitats and survey sites. Nancy Newhouse and staff provided maps and advice. Ted Antifeau provided helpful literature. We are grateful to all landowners who allowed us to conduct surveys on their lands. Jenny Wu (COSEWIC Secretariat) prepared the map of Canadian distribution, provided a basemap for other maps used in this report, and calculated EO and IAO values. Moretta Fredericks compiled information on gastropod surveys as part of the *Living Landscapes* Project and searched the Royal British Columbia Museum records for the species. Jean-Marc Gagnon (Canadian Museum of Nature), Maureen Zubowski (Royal Ontario Museum), and Jochen Gerber (Field Museum of Natural History) kindly searched their databases for specimen records. Aleta Karstad generously allowed the use of her painting of the Magnum Mantleslug on the title page.

The following government contacts were consulted:

BC Ministry of Environment: Ted Antifeau, Phil Belliveau (no response), Orville Dyer, David Fraser, Grant Furness, Jennifer Heron, Mike Peterson, Al Soobotin, Tory Stevens; BC Conservation Data Centre: Lea Gelling; Canadian Wildlife Service: Shelagh Bucknell (no response), David Cunnington, Rhonda Millikin (no response); Parks Canada: Gilles Seutin (no response); Gregg Walker; COSEWIC Secretariat: Alain Filion, Jenny Wu, Sonia Schnobb, Angèle Cyr, Michele Rodrick.

Funding for this assessment was provided by Environment Canada. Fieldwork conducted in support of the preparation of this status report in 2010 was augmented by similar surveys for terrestrial gastropod species at risk in the Kootenay Region conducted by Biolinx Environmental Research Ltd. under contract for BC Ministry of Environment.

INFORMATION SOURCES

Austin, M.A., D.A. Buffett, D.J. Nicolson, G.G.E. Scudder, and V. Stevens (eds.). 2008. Taking Nature's Pulse: The Status of Biodiversity in British Columbia. Biodiversity. Victoria, British Columbia. 268 pp. Web site: www.biodiversitybc.org [accessed March 2010].

Backeljau, T., pers. comm. 2011. *Email correspondence to R. Forsyth*. February 2011. Professor, Department of Invertebrates, Malacology Section, Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

BC Stats 2010. Population Projections - BC and Regional. Web site: http://www.bcstats.gov.bc.ca/data/pop/pop/Project/P34BCIntro.pdf [accessed July 2010].

B.C. Ministry of Forests, Mines and Lands. 2010. The State of British Columbia's Forests, 3rd ed. Forest Practices and Investment Branch, Victoria, British Columbia. Web site: www.for.gov.bc.ca/hfp/sof/index.htm#2010_report [accessed June 2011].

Bouchet, P., and J.P. Rocroi. 2005. Classification and nomenclator of gastropod families. Malacologia 47(1-2):1-397 pp.

Brunsfeld, S.J., J. Sullivan, D.E. Soltis, and P.S. Soltis. 2001. Comparative phylogeography of Northwestern North America: A synthesis. Pp. 319-339, *in* J. Silvertown and J. Antonovics (eds.). Integrating Ecological and Evolutionary Processes in a Spatial Context. Blackwell Science, Oxford.

Brunson, R. B., and N. Kevern. 1963. Observations of a colony of Magnipelta. Nautilus July 1963 77(1):23-27.

Copley, C., pers. comm. 2010. *Email correspondence to K. Ovaska*. October - November 2010. Royal British Columbia Museum, Victoria, British Columbia.

Cordeiro, J. 2004. *Magnipelta mycophaga*. Populations/occurrence delineation. *In* NatureServe. 2010. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Web site: http://www.natureserve.org/explorer [accessed November 2010].

Duncan, N. 2005. Monitoring of sensitive mollusk populations following low-intensity wildfire in old growth coniferous forest. Unpublished report prepared for USDI Bureau of Land Management, Roseburg District Office, Oregon 97470, USA.

Duncan, N. 2008. *Magnipelta mycophaga* - species fact sheet. Web site: http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/sfs-ig-magnipelta-mycophaga-2008-04.doc [accessed November 2010].

Forsyth, R.G. 1999. Terrestrial gastropods in the Columbia Basin, British Columbia. Royal British Columbia Museum, Living Landscapes. Web site: http://www.livinglandscapes.bc.ca/cbasin/molluscs/introduction2.html [accessed June 2010].

Forsyth, R.G. 2004. Land Snails of British Columbia. Royal British Columbia Museum: Victoria, British Columbia, Canada. 188 pp.

Forsyth, R., pers. comm. 2010, 2011. *Email correspondence to K. Ovaska*. May 2010, May 2011. Research Associate, Royal British Columbia Museum, Victoria, British Columbia.

Frederick, M. pers. comm. 2010. *Email correspondence to K. Ovaska*. October 2010. Royal British Columbia Museum, Victoria, British Columbia.

Frest, T.J., and E.J. Johannes. 1995. Interior Columbia Basin mollusk species of special concern. Final Report to Interior Columbia Basin Ecosystem Management Project. Deixis Consultants, Seattle. 274 pp.

*Gervais, J.A., A. Traveset, and M.F. Willson. 1998. The potential for seed dispersal by the Banana Slug (*Ariolimax columbianus*). The American Midland Naturalist 140:103-110.*

Hendricks, P., B.A. Maxell, S. Lenard, and C. Currier. 2007. Land Mollusk Surveys on USFS Northern Region Lands: 2006. A report to the USDA Forest Service, Northern Region. Montana Natural Heritage Program, Helena, Montana. 11 pp. plus appendices.

Huggard, D., pers. comm. 2009. *Email correspondence to K. Ovaska*. December 2009. Consultant, Vancouver, British Columbia.

Idaho Conservation Data Center. 2005. Idaho Department of Fish & Game. Web site: http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_appf/Magnum%20Mantleslug.pdf [accessed November 2010].

Leonard, W.P., L. Chichester, C.H. Richart, and T.A. Young. 2011. *Securicauda hermani* and *Carinacauda stormi*, two new genera and species of slug from the Pacific Northwest of the United States (Gastropoda: Stylommatophora: Arionidae), with notes on *Gliabates oregonia* Webb 1959. Zootaxa 2746:43-56.

Lepitzki, D.A.W., pers. comm. 2011. *Email correspondence to K. Ovaska*. May 2011. Wildlife Systems Research, Banff, Alberta. Co-chair, Molluscs SSC of COSEWIC.

Lucid, M., L. Robinson, S. Cushman, L. Allen, and S. Cook. 2010. Inland Maritime Initiative: maintaining multi-species connectivity in a changing climate. IMI annual report. 15 p.

Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, Virginia. 57 pp.

McGraw, R., N. Duncan, and E. Cazares. 2002. Fungi and other items consumed by the Blue-Gray Taildropper slug (*Prophysaon coeruleum*) and the Papillose Taildropper slug (*Prophysaon dubium*). The Veliger 45:261-264.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia. BC Ministry of Forests, Victoria, BC. 330 pp.

Mining-technology.com. 2010. Web site: http://www.mining-technology.com/projects/fording/ [accessed July 2010].

Miskelly, J. pers. comm. 2010. *Email correspondence to K. Ovaska*. January 2010. Research Associate, Royal British Columbia Museum, Victoria, British Columbia.

Montana Field Guide. Undated. Magnum Mantleslug — *Magnipelta mycophaga*. Web site: http://Field Guide.mt.gov/detail_IMGAS61010.aspx [accessed July 2010, January 2012].

Müller, J., C. Bässler, C. Strätz, B. Klöcking, and R. Brand. 2009. Molluscs and climate warming in a low mountain range national park. Malacologia 51:89-109.

NatureServe. 2010, 2012. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Web site: http://www.natureserve.org/explorer [accessed November 2010, January 2012].

Ovaska, K., and L. Sopuck. 2008. Surveys for terrestrial gastropods at risk in southeastern British Columbia in 2008, and synthesis with 2007 data. Prepared by Biolinx Environmental Research Ltd. for BC Ministry of Environment, Victoria. 25 pp.+ appendices.

Ovaska, K., and L. Sopuck. 2009. Surveys for terrestrial gastropods at risk within Ktunaxa traditional territory, October 2009. Prepared by Biolinx Environmental Research Ltd. for BC Ministry of Environment, Victoria, British Columbia. 27 pp.

Ovaska, K., L. Sopuck, and J. Heron. 2010. Gastropod surveys on private and municipal land in the Kootenay region, British Columbia, B.C. Ministry of Environment, Terrestrial Conservation Science Section, UBC Campus, 315 - 2202 Main Mall, Vancouver, British Columbia. 47 pp.

Pilsbry, H.A. 1948. Land Mollusca of North America (north of Mexico). The Academy of Natural Sciences of Philadelphia, Monograph 3, 2(2):i-xlvii, 521-1113.

Pilsbry, H.A. 1953. *Magnipelta*, a new genus of Arionidae from Idaho. The Nautilus 67:37-38.

Pilsbry, H.A., and R.B. Brunson. 1954. The Idaho-Montana slug Magnipelta (Arionidae). Notulae Naturae 262:1–6.

Reise, H., pers. comm. 2010. *Email correspondence to K. Ovaska*. August 2010. Senckenberg Museum of Natural Hisory, Görlitz, Germany.

Santos, X., V. Bros, and A. Miño. 2009. Recolonization of a burned Mediterranean area by terrestrial gastropods. Biodiversity and Conservation 18:3153–3165.

Turgeon, D.D., J.F. Quinn, A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd edition. American Fisheries Society Special Publication 26: ix + 526 pp.

Webb, G.R., and R.H. Russell. 1977. Anatomical notes on a *Magnipelta*: Camaenidae? Gastropodia 1(10):107-108.

BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Kristiina Ovaska, Ph.D., M.Sc., received her doctoral degree in biology from the University of Victoria, after which she completed two post-doctoral studies in animal behaviour and population biology with McGill University and University of British Columbia, respectively. Presently, she is a partner in Biolinx Environmental Research Ltd. and a research associate at the Department of Forest Sciences, University of British Columbia. Her experience with terrestrial gastropods includes research into effects of forestry practices, studies on patterns of abundance and distribution of species at risk, and numerous surveys in different parts of British Columbia, including the Kootenays where she has searched for the Magnum Mantleslug and other species at risk from 2007 to 2010. She has prepared status reports, recovery strategies, a multi-species action plan, and best management practices guidelines for terrestrial gastropods. Her photographs of gastropods appeared in the Royal BC Museum Handbook "Land Snails of British Columbia" by R. Forsyth. She is the author of more than 40 publications in the refereed scientific literature, including several papers on terrestrial gastropods.

Lennart Sopuck, M.Sc., RPBio, has studied a wide variety of wildlife species over the past 25 years. His expertise includes assessing and mitigating effects of various human activities on wildlife, including species at risk. Together with Dr. Ovaska, he is a partner of Biolinx Environmental Research Ltd. and has conducted numerous survey and research projects on terrestrial gastropods of British Columbia. He is co-author of several status reports, recovery strategies, a multi-species action plan, and management documents for terrestrial gastropod species.

COLLECTIONS EXAMINED

The following collections were queried (specimens not examined):

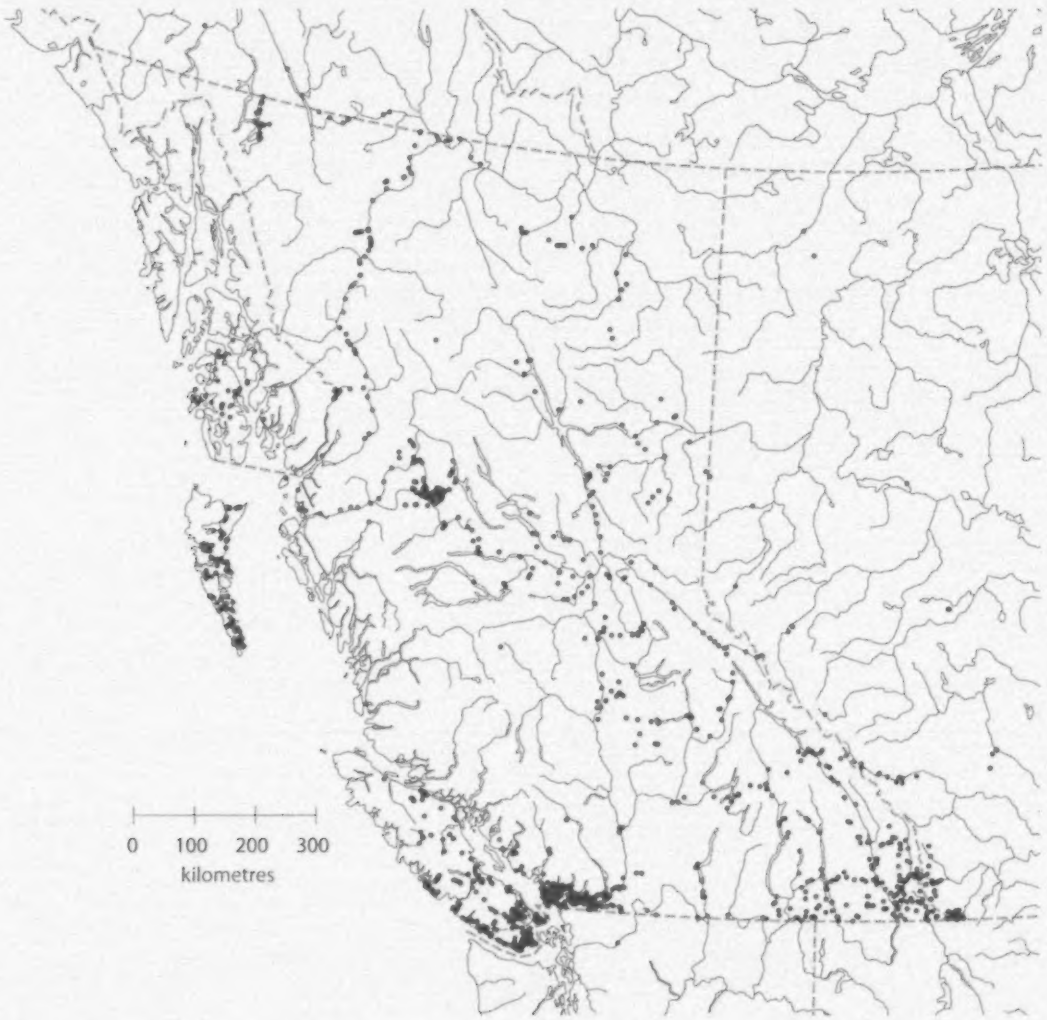
Royal British Columbia Museum, Victoria, British Columbia (Moretta Fredrick; contacted by email 22 May 2010). 2 records of *M. mycophaga* (near Nancy Green Provincial Park; Stagleap Provincial Park; photograph of latter published in Forsyth (2004)

Royal Ontario Museum, Ottawa, Ontario (Maureen Zuboski; contacted by email 22 May 2010). No Canadian records of *M. mycophaga*

Canadian Museum of Nature, Ottawa, Ont. (Jean-Marc Gagnon; contacted by email Nov 2010). No Canadian records of *M. mycophaga*

Field Museum of Natural History, Chicago, USA (Jochen Gerber; contacted by email 22 May 2010). No Canadian records of *M. mycophaga*

Appendix 1. Distribution of searches for terrestrial molluscs in British Columbia and neighbouring provinces and territories from 1999 through September 2011. Each dot represents a locality where a search for terrestrial snails and slugs has occurred; methodology includes visual searches with or without substrate manipulation as well as forest floor litter samples. This compilation only includes records from Biolinx Environmental Research Ltd., Forsyth, and Wildlife Systems Research (= Lepitzki); some of these records have been included in reports and publications while other records are unpublished (map prepared by R. Forsyth).



Appendix 2. Sites surveyed for terrestrial gastropods in the Kootenays by Biolinx Environmental Research Ltd. from 2008 - 2010, showing observations of *Hemphillia camelus* (Pale Jumping-slug) and *Magnipelta mycophaga* (Magnum Mantleslug).